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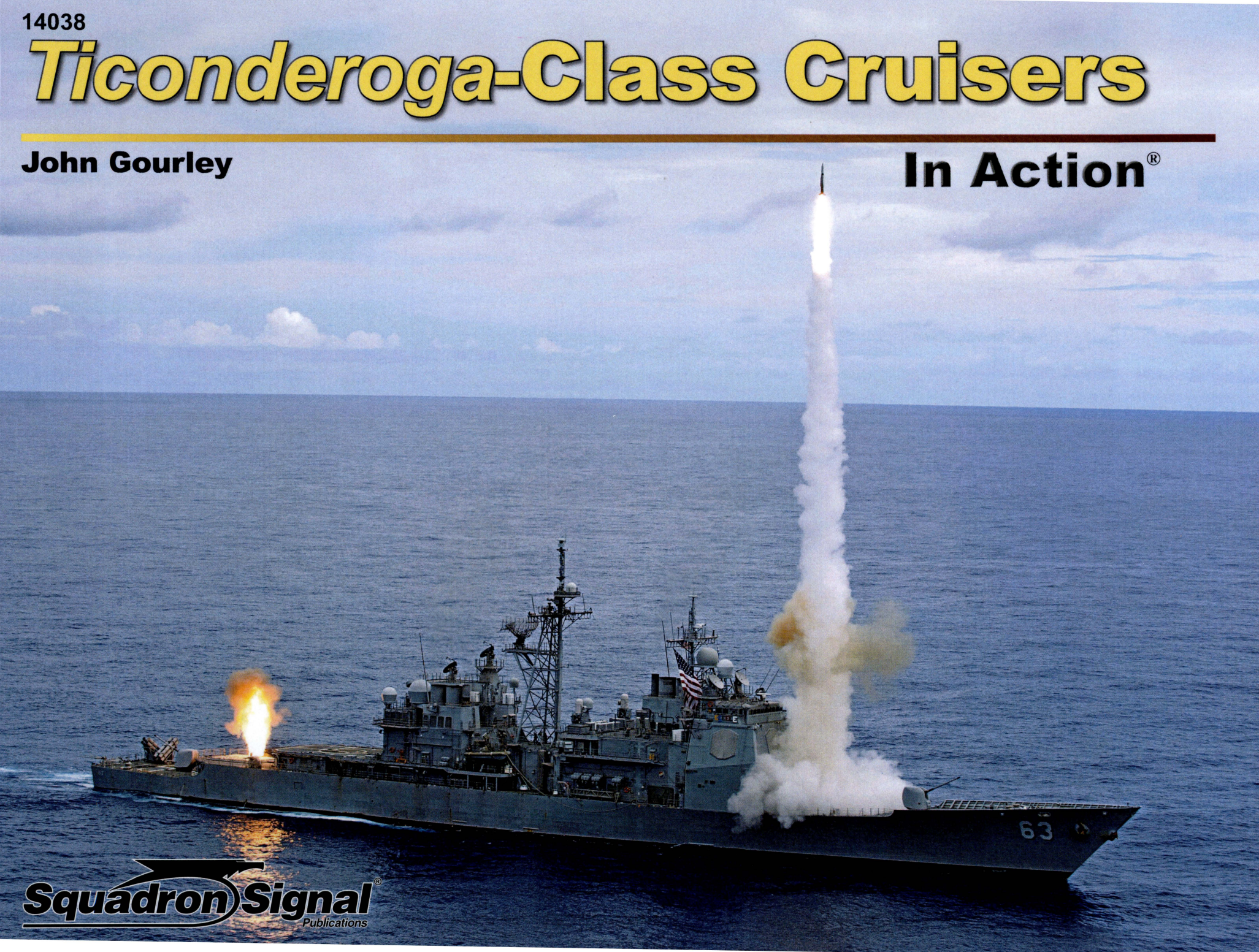
# Ticonderoga-Class Cruisers

John Gourley

## In Action®




Squadron Signal® Publications

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*Written by John Gourley*

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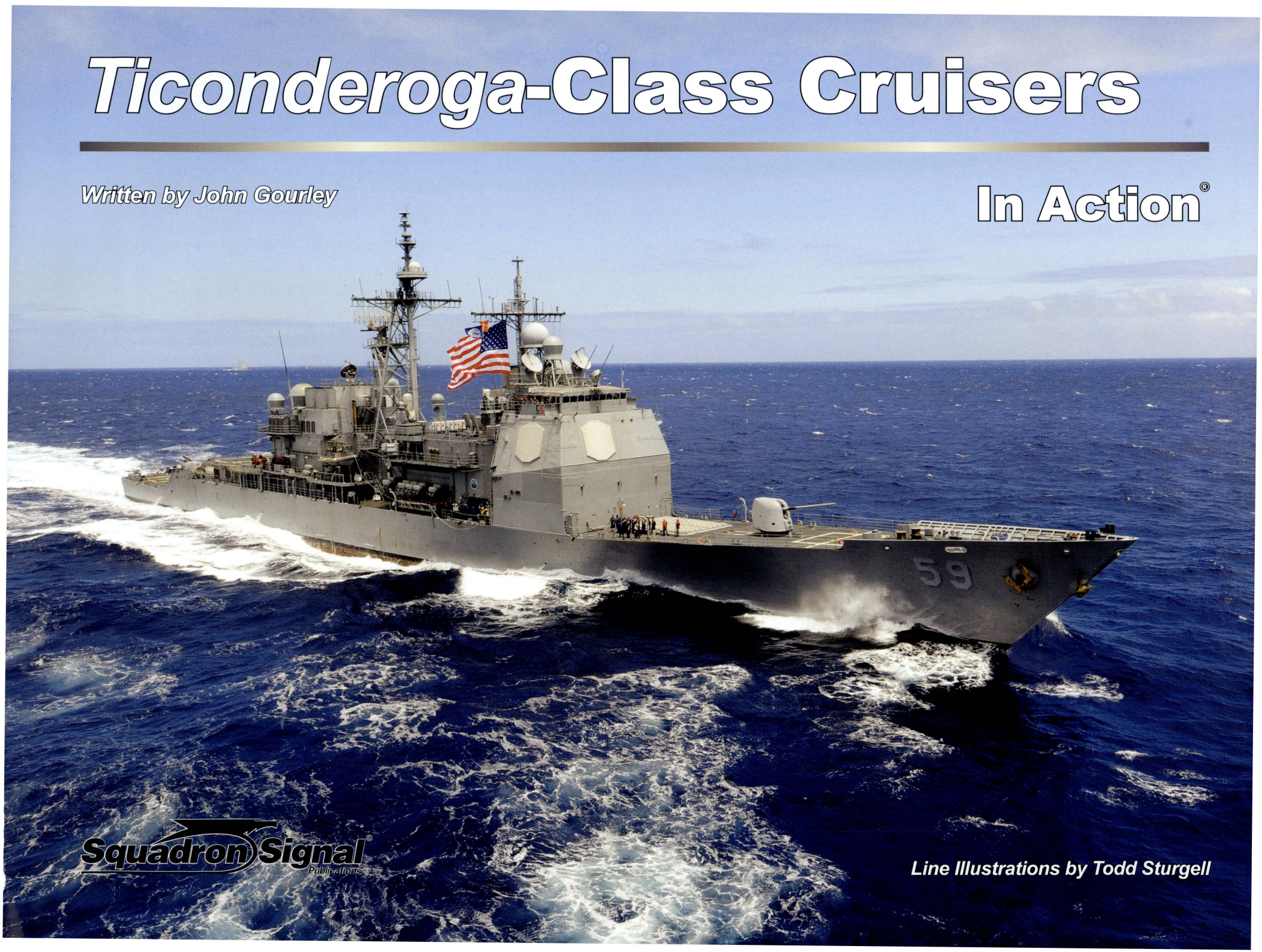

Squadron Signal Publications®

*Line Illustrations by Todd Sturgell*

**(Front Cover) Aegis guided-missile cruiser USS *Cowpens* (CG-63) fires SM-2 missiles from its vertical launch system (VLS) modules forward and aft during a live-fire exercise at a simulated anti-ship missile in the Pacific on 18 July 2012. The Aegis radar and VLS have revolutionized surface warfare capabilities. (Paul Kelly / U.S. Navy)**

**(Back Cover) Guided-missile cruiser (CG) 56 *San Jacinto* approaches to refuel at sea after its modernization program fit with SPQ-9B (S = water (surface ship), P = radar, Q = special or combination) radar behind the USC-38 radome (U = general utility, S = special or combination, C = communications) on 6 June 2012. (Tommy Lamkin / Navy)**

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**(Title Page) The guided-missile cruiser USS *Princeton* (CG-59) pulls alongside the military sealift command fleet replenishment oiler USNS *Henry J. Kaiser* (T-AO 187) to refuel at sea with biofuel during The Great Green Fleet demonstration portion of the Rim of the Pacific 2012 exercise on July 18, 2012. (Andrew M. Jandik / U.S. Navy)**

# Acknowledgements

I give my thanks to Lou Drendel for getting me started, and to A.D. Baker III, Dr. Norman Friedman, Robert F. Dorr and Eric Wertheim for their friendship and assistance on many naval topics during the creation of this book and my other books in this series.

# Dedication

I dedicate this book to my daughter Jacqueline for her continued support. I also dedicate this book to the crews of all *Ticonderoga*-class cruisers as they maintain a constant presence on the oceans during the day and night, in all weather extremes, far from home, while they work to keep the sea lanes open, safe and navigable in times of peace and war.

# Introduction

In the early 1970s, the U.S. Navy recognized the need to increase the number of cruisers with advanced capabilities to provide effective escort and protection for planned nuclear-powered aircraft carriers (CVN) of the *Nimitz* class. Freed from the requirement to refuel at sea, atomic-fueled vessels benefited from increased flexibility and reduced dependence on other support vessels to maintain their underway mobility.

The intent was to build a new guided-missile destroyer (DDG) class of nuclear-powered escort cruisers with the ability to strike targets at sea or on land. This class would also field the new Aegis radar system with Standard Missiles to protect surface action groups from air attack. Once the DDG class was built, overall cruiser numbers would be sufficient to escort a single carrier battle group with up to four of these ships.

Two design programs were initiated to build a new cruiser class and increase the number available to the fleet. One program considered in 1974 was the nuclear strike cruiser (CSGN). These ships would be approximately 17,200 tons and equipped with Aegis and Standard Missiles (SM). The other program involved the construction of seven more ships, known as the nuclear-powered guided missile cruiser (CGN) 42 class, a modified *Virginia* of 12,000 tons. Two hull designs were selected. One design was a conventional shape. The other design featured a water-plane shape. The water-plane hulls were tested with anti-roll stabilizer fins and bilge keels placed at various test locations. The models were then evaluated at various speeds and sea conditions in a test tank with favorable results.

Costs for a single CSGN ship were estimated to be double the price of a single *Kidd*-class DDG-963 vessel in 1977. A single modified CGN-38 *Virginia* was projected to be 30 percent to 50 percent more than the cost of one DDG-963 ship.

Congress rejected both designs and did not authorize the $1.7 billion necessary for this increased number of ships. Instead, planners decided to build the new cruisers on modified destroyer (DD) 963 *Spruance* hulls with gas-turbine propulsion.

Existing cruiser types, such as the *Virginia* class of four ships, two examples of the *California* class, one each of the *Bainbridge*, *Long Beach* and *Truxtun* classes, numbered too few to provide carrier strike groups with sufficient nuclear propelled escorts.

All of these cruisers types were built with nuclear power plants. Physical capability to pace the carriers was not an issue. However, construction and maintenance costs along with an inability to economically retrofit these vessels with advanced naval weaponry, such as new Standard Missiles and vertical launch systems (VLS) modules, made these vessels undesirable. For example, armored box launchers on the *Virginia*-class cruisers resulted in little to no capability for these ships to perform vertical replenishment from helicopters on the aft platform because the two large boxes that contained four Tomahawks each occupied most of the former helicopter operations space.

Planners proposed the installation of the Aegis system on CGN-9 *Long Beach* in 1975. This idea was eliminated upon detailed examination because the radar system overhaul would have been too costly.

All these ships were eventually decommissioned by the late 1990s.

***Ticonderoga*** **steams ahead during its first sea trials on 5 May 1982. It features a Mk 26 twin-arm missile launcher, uncluttered deckhouses, and masts with both an AS-3018 ultra-high frequency (UHF) satcom antenna and a Mk 80 missile guidance radar. (Ingalls)**

Guided-missile cruiser *Normandy* (CG-60) sails in the Indian Ocean on 18 September 2007. The battle ensign of *Normandy* streams from the port side. The ship had recently received overhaul work, which included fresh paint on the entire hull and superstructure. Such down-time work is necessary to maintain everything from running gear to "landing" old hardware ashore while simultaneously installing new items. (Vincent J. Street / U.S. Navy)

*Vella Gulf* (CG-72) attempts to avoid and outrun a simulated torpedo in the Indian Ocean on 12 July 2008. Such maneuvers are practiced regularly to keep the crew prepared. Another method to defeat a torpedo threat is to stream an SLQ-32 Nixie countermeasure (S = surface ship, L = countermeasures, Q = special or combination) from one of the two small doors located on the starboard side of the transom. It produces signals that attract and lure the incoming weapon away from the ship. (Jason R. Zalasky / Navy)

# *Ticonderoga* in detail

The current guided-missile cruiser program was ordered into production in fiscal year 1978. The foundation of the class started as destroyers equipped with guided missiles. These ships were built on modified steel hulls of increased length used in the DD-963 *Spruance* destroyer. They were 567 feet long rather than *Spruance*'s 529-foot length.

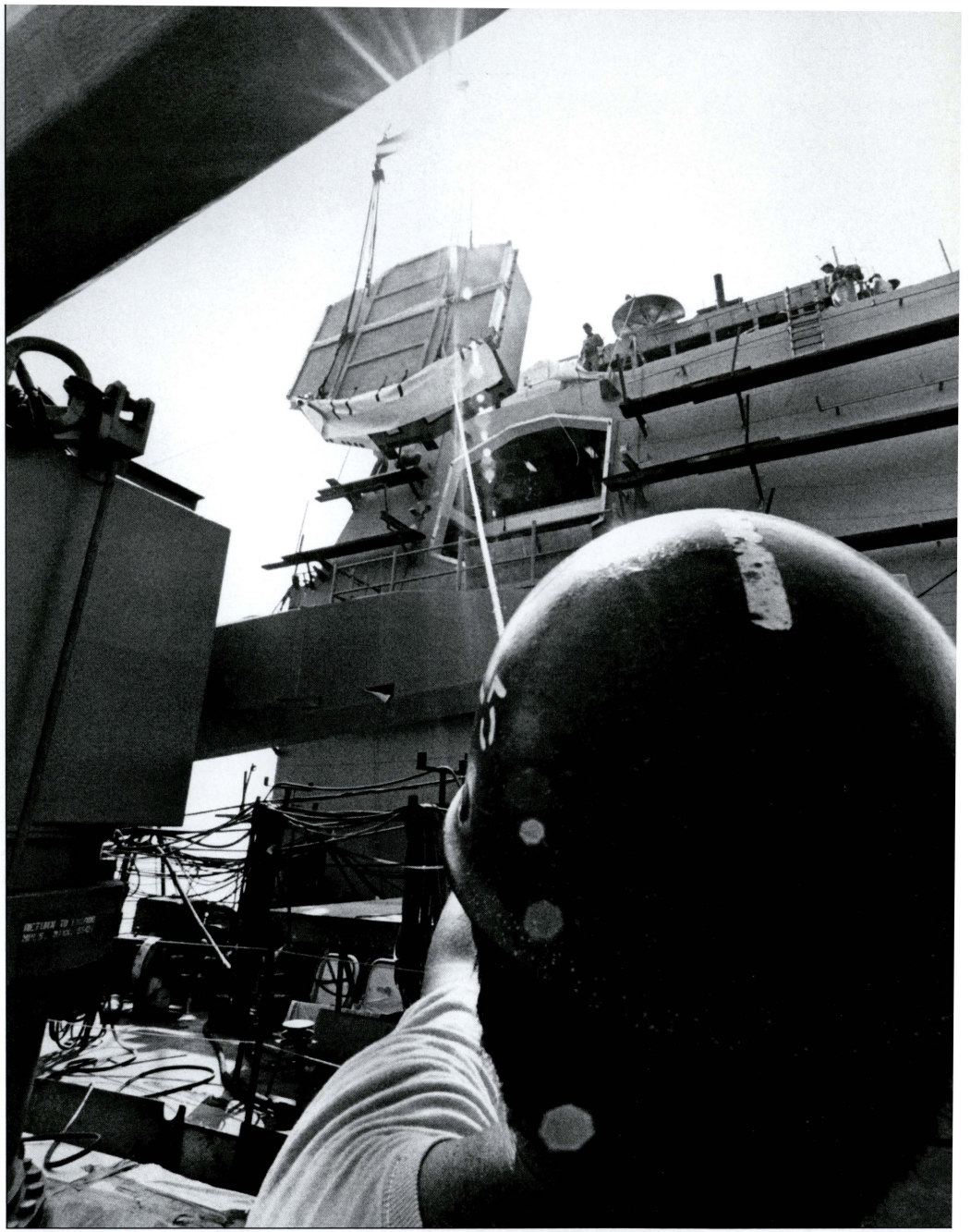
USS *Ticonderoga* (DDG-47) was built at Ingalls Shipbuilding in September 1978. It was launched in 1981 and was put into service in January of 1983. Installation of the Aegis Combat System along with dedicated anti-air-warfare, undersea warfare, anti-surface warfare and naval surface fire support missions resulted in a designation change from DDG-47 to CG-47 (cruiser-guided missile) in January 1980.

These new ships were designed to operate cheaper and incorporate the Aegis Mk 7 system. The Aegis system was composed of four phased-array radars, four Mk 80 target illuminators and two Mk 26 missile launchers, a hangar for two SH-2F Seasprite (CG-47 and CG-48) or SH-60B Seahawk helicopters. Mk 26 launchers held the latest Standard Missiles (SM-2 MR Block I). *Vincennes* (CG-49) and later ships also carry up to eight rocket-guided missile (RGM) 84 Harpoon anti-ship missiles.

*Ticonderoga*-class vessels eventually totaled 27. Ingalls Shipbuilding built 19 and Bath Iron Works completed eight. Modular construction techniques were used for the first time. Builders used computer-aided design and computer-aided manufacturing software programs to make sub-assemblies with pre-installed air ducts, wires, cables and pipes. The sections were mated to form larger modules, which were then placed and joined together. This construction method made shipyard assembly more efficient and streamlined.

Sea trials proved the design to be capable and effective at sea. Post-trial modifications included steel bulwarks added to the bow (later constructed of aluminum to reduce overall top weight) as the ship tended to pitch its bow deep into waves while underway in heavy sea states. Consequently, water ran down the deck and would damage hardware. This phenomenon was even more pronounced with a full load of missiles in the forward magazine. Additional reinforcement of the forward deckhouse was intended to minimize the effects of water surge on deck and against the forward section of the superstructure.

Otherwise, maneuverability was similar to the *Spruance* class. At 25 knots, CG-47 *Ticonderoga* could turn 90 degrees from a previously set course in two ship lengths. Hull length for all ships was 567 feet with a beam of 55 feet. Draft was 34 feet. No fin stabilizers are fitted. Tonnage for *Ticonderoga* was 7,646 tons light/10,142 tons full load. *Yorktown* (CG-48) was 7,592 tons light/10,090 full load. The remainder are 6,997 to 7,242 tons light with a displacement of 9,763 to 10,010 tons fully loaded. Propulsion to speeds in excess of 30 knots was provided by four General Electric LM2500 gas turbines, which drove two shafts for a combined sustained total of 86,000 shp (shaft horsepower) (43,000 shp per shaft). Maximum short-duration shaft horsepower is 100,000 shp. Propellers were controllable with reversible-pitch designs of five-blades each. The port propeller rotated counter-clockwise while the starboard propeller rotated clockwise. Aft of each prop is a single rudder. Electric power from three 2,500 kw 501K gas turbine sets provided a total power output of 7,500 kw. Range at 20 knots is 6,000 nautical miles with a full fuel load



***Ticonderoga* (CG-47) gets the first SPY-1A Aegis antenna while fitting out at the Ingalls Shipbuilding facility in Pascagoula, Mississippi, on 10 Jan 1981. The four radar units had to be within one half of one inch and level with each other to guarantee overall radar performance. The Aegis installation was a sophisticated advancement in shipboard surveillance capabilities. (Litton Ingalls Shipbuilding / U.S. Navy)**

Capt. Blaire Ireland, second from right, and others attend the USS *Antietam* (CG-54) keel laying event on 15 November 1984. Capt. Ireland was the Aegis Project Officer. Once the keel was laid, shipyard construction and assembly began in earnest. (U.S. Navy)

Sailors man the *Ticonderoga* combat information center while off the Lebanese coast on 1 March 1984. The screens show tracks of aircraft and their flight paths, land masses and lists track numbers to contacts assigned by the Aegis system. (Joe Harrison / Navy)

*Ticonderoga* shows the forward face of its SPY-1A Aegis radar system on 10 May 1983. Four arrays provide 360 degrees of coverage. Above the bridge windows are two high frequency whip antennas beside a WSC-3 UHF satcom "trash can" antenna. Above the SPQ-9A radome is an AS-2953 / SPS-55 navigation radar on the starboard mast yardarm. A combined surface and underwater radio navigation aid (WRN) 5 / CA-3086 navigation satellite antenna is on the port yardarm. This navigation satellite antenna was an early model. (James Manley / U.S. Navy)

of 2,000 tons of marine fuel. Crew compliment was 23 officers and 327 enlisted.

The first five ships of this class (CG-47 through CG-51) were built with two Mk 26 twin-arm missile launchers. One was located forward, and one was located aft. Both could fire the SM-2 MR Standard Missiles and the RUR-5 anti-submarine rocket (ASROC).

The total number of Standard Missiles carried was 68 with 44 aft, 24 forward along with 20 rounds of the ASROC. RGM-84 Harpoon surface-to-surface anti-ship missiles, operated by the SWG-1 ship fire-control system, were located on a platform aft. A total of eight can be deployed on the Mk 141 stand-alone shock-hardened launcher. The launch canisters were angled at 35 degrees.

Forward and aft main gun armament includes two 5-inch (127mm) dual-purpose guns, which can engage air or surface targets. For close-in protection against anti-ship cruise missiles, two 20mm Mk 15 CIWS (close-in weapon system) were positioned amidships on elevated platforms. For defense against small craft, four .50 caliber machine guns are located at crew watch stations along the hull sides.

Two torpedo launchers are located behind shutters along the port and starboard aft sides of the hull and are of the triple-tube Mk 32 Mod 14 type, each tube with a diameter of 12.75-in / 324mm. These launch the Mk 46 torpedo, which is also the payload of the ASROC. A total of 36 Mk 46 torpedoes can be stored in an armored magazine on board.

*Ticonderoga* and *Yorktown* put to sea with two SH-2F Seasprite LAMPS I (light airborne multi-purpose system) helicopters. USS *Vincennes* (CG-49) and later ships operated with two SH-60B Seahawk LAMPS III. Both helicopters could perform surveillance, drop sonobuoys, relay information back to the ship and launch Mk 46 torpedoes.

USS *Bunker Hill* (CG-52) through *Vella Gulf* (CG-72) had two Mk 41 Mod 0 vertical launch system (VLS) modules installed. The modules replaced the Mk 26 missile launcher system. Vertical launch systems provided a total of 116 missiles stored in vertical canisters with 58 missiles forward and 58 aft. The modules could launch versions of the SM-2 Standard Missiles as well as Tomahawk and the vertical-launch ASROC. The RUM-139. Harpoon, gun armament, and torpedo arrangement are the same for all ships. A crane in each VLS module could reload canisters after the missiles were fired.

Kevlar armor protects areas around both vertical launch system (VLS) modules and internal spaces such as the combat information center compartment and spaces outfitted with electronic components.

Electronic systems included the surface search radar SPS-53 installed on CG-47 *Ticonderoga* and CG-48 *Yorktown*. *Vincennes* (CG-49) through *Port Royal* (CG-73) had the SPS-64 surface navigation radar set fitted. A single SPS-55 surface search / navigation set was installed on all ships. The SPS-49 long-range two-dimensional air search radar was located on an elevated platform on the mainmast. Also installed on all ships are the four Mk 80/SPG-62 illuminators for Standard Missiles guidance via the Mk 99 fire control system. Aegis SPY-1A (S = ship, P = radar, Y = surveillance and control) radar arrays were fitted into the deckhouses of all ships. SPY-1A was fielded on CG-47 through CG-58. USS *Princeton* (CG-59) through CG-73 *Port Royal* were provided the upgraded SPY-1B. A SPQ-9A gunfire control radar was located on the foremast above the bridge and enclosed in a protective radome.

The URN-25 TACAN (tactical control and navigation) antenna was located at the

**Officials and guests attend the USS *Ticonderoga* commissioning ceremony at Ingalls Shipbuilding in Pascagoula, Mississippi, on 22 January 1983. (Griffin / U.S. Navy)**

**Crewmen "man the rails" during the commissioning ceremony for CG-47 *Ticonderoga* at Ingalls Shipbuilding in Pascagoula on 22 January 1983. (Griffin / U.S. Navy)**

USS *Yorktown* (CG-48) is docked for maintenance at Moon Engineering Co. on the Elizabeth River on 25 September 1990 in Portsmouth, Virginia. It has twin-arm Mk 26 missile launchers forward and aft. *Yorktown* was the second of the *Ticonderoga* class. Its keel was laid down on 19 October 1981. It launched on 17 January 1983 and was decommissioned on 10 December 2004. Beside it is the first amphibious transport dock (landing platform/dock) LPD-4 *Austin*. Eventually, 11 *Austin*-class ships were built. (Martin Norman / Navy)

very top of the mainmast while the identification radar UPX-29 IFF (identification friend or foe) 64-element array surrounds the outside edge of the platform. Inside a nearby radome is the SQQ-28 (S = ship, Q = sonar and underwater sound, Q = special) LAMPS data-link reception antenna. Mainmast design on CG-47 and CG-48 was a quadruped type replaced on CG-49 *Vincennes* and follow-on ships by a tripod design, which trimmed nine tons off of topside weight. SAT-2 ship infrared blinkers are located at the ends of the mainmast yardarms.

Electronic warfare (EW) equipment was also included. The Mk 36 super rapid-blooming off-board chaff dispensers and the SLQ-32(V)3 active EW jammer both foil attacks from radar-guided missiles. The Mk 50 floating radar decoy system deploys SLQ-49 inflatable reflectors by means of the Mk 166 launcher system. The sonar system is controlled by means of the SQQ-89 sonar suite of sensors. The SQS-53A (S = ship, Q = sonar, S = detecting, range and bearing, search) was installed in CG-47 through CG-55. Cruisers CG-56 through CG-73 received the SQS-53B sets, these sets are located in a bulbous forefoot fairing in the bow below the waterline. *Antietam* (CG-54) through *Port Royal* (CG-73) had the SQR-19 (S = ship, Q = sonar, R = receiving or passive detecting) TACTAS (tactical towed-array sonar) installed to detect underwater threats through a series of 16 hydrophones encapsulated within a long cable and towed behind the ship. Eight hydrophones detect sound in the very-low frequency range while four are sensitive to low frequency. Two are sensitive in the medium frequency range, and two detect high frequency emissions. Also designed to be streamed from the transom was the SLQ-25 Nixie, which generates ship sounds to lure torpedoes away from the targeted vessel.

The Prairie Masker air bubbler system supplies air to the lead edges of the propeller blades on these ships. The system helps hide the hydrodynamic noise emitted by propeller rotation. It also reduces the metal wear effect known as cavitation. Prairie Masker bands are located in belts along the exterior of the hull sides in areas where the engineering sections are located. The streams of bubbles are an effective method to conceal noises the ship itself generates. This system helps because submarine passive detection reveals noises generated by surface ships, but the ship types cannot be identified with any certainty.

Early versions of satellite communications antennas were used at sea by the late 1980s. The OE-82 "trash can" provided two-way links in the UHF band and a SSR-1 received fleet broadcasts in guided-missile cruiser class ships. Even more satellite communications followed as space-based assets grew to provide more signal-band coverage, wider bandwidths and faster speeds to send and receive messages.

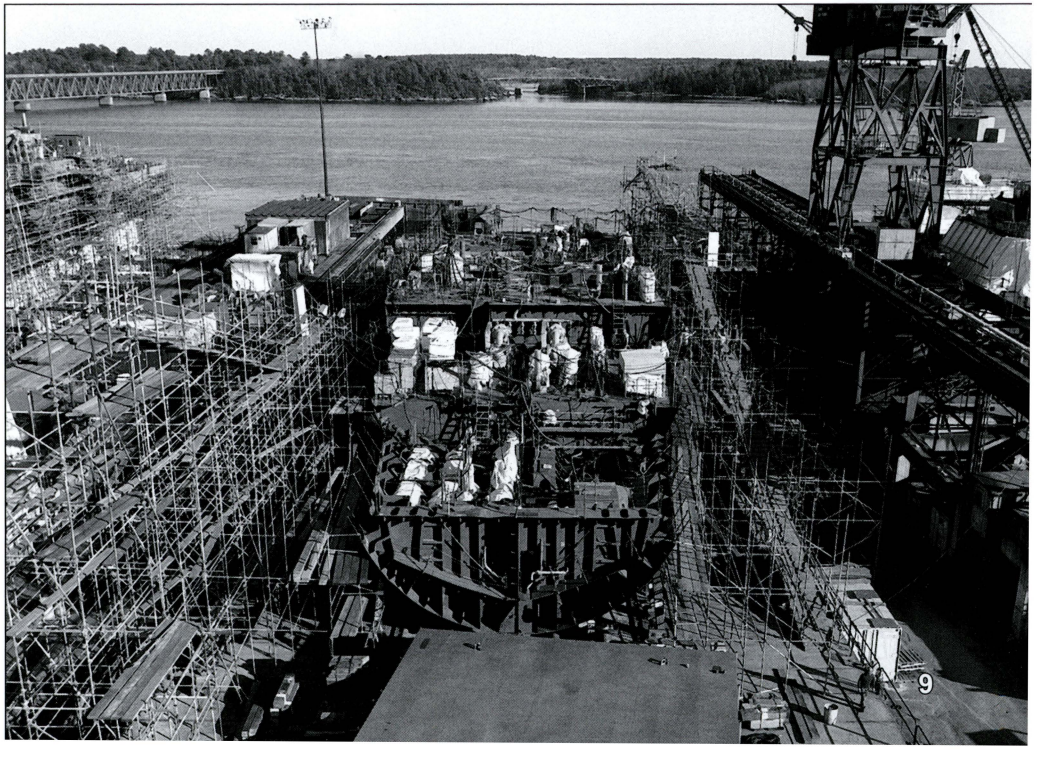
*Ticonderoga* was authorized for construction in fiscal year 1978. By 1983, each ship was estimated to cost $1 billion to build. Annual operation costs for each ship was estimated to be approximately $28 million.

*Ticonderoga* is the fourth vessel to bear this name. Ticonderoga is a word derived from the Iroquois Indian language. It means, "between two waters."

The names of the remaining 26 ships in the *Ticonderoga* class fall into several categories. Twelve ships share their names with former World War II aircraft carriers. Other ships were named after battles and campaigns in U.S. military history. USS *Princeton* (CG-59) is named for the victories of George Washington over the British in and around the area of the town of Princeton, New Jersey. *Antietam* (CG-54), CG-62 *Chancellorsville*, CG-64

**The ship plaque of USS *Ticonderoga* is made of brass and bolted in place on 11 February 1983. It was polished on a regular basis. *Ticonderoga* entered service on 22 January 1983 and was decommissioned on 30 September 2004. (U.S. Navy)**

**USS *Monterey* (CG-61) is under construction at Bath Iron Works in Bath, Maine, on 17 November 1987. The ship was 20 percent completed. (Bath Iron Works / U.S. Navy)**



USS *Cowpens* (CG-63) is underway in calm seas on 1 May 2006. The shadow of its assigned helicopter is silhouetted against the forward deckhouse. *Cowpens* was built in Maine at the Bath Iron Works in the late 1980s and placed in service with the Pacific Fleet in 1991. A WSC-6 (W = water surface and underwater combined, S = special or combination, C = communications [two way]) super-high frequency (SHF) satcom antenna is housed within the large gray radome to the left of the forward exhaust stacks. White radomes aft of the stacks, are for the two Phalanx close-in weapon system devices. The eight gray canisters on rails alongside the deckhouse are life rafts. (Nathanael T. Miller / Navy)

*Gettysburg* and CG-67 *Shiloh* are named for American Civil War battles from the 1860s.

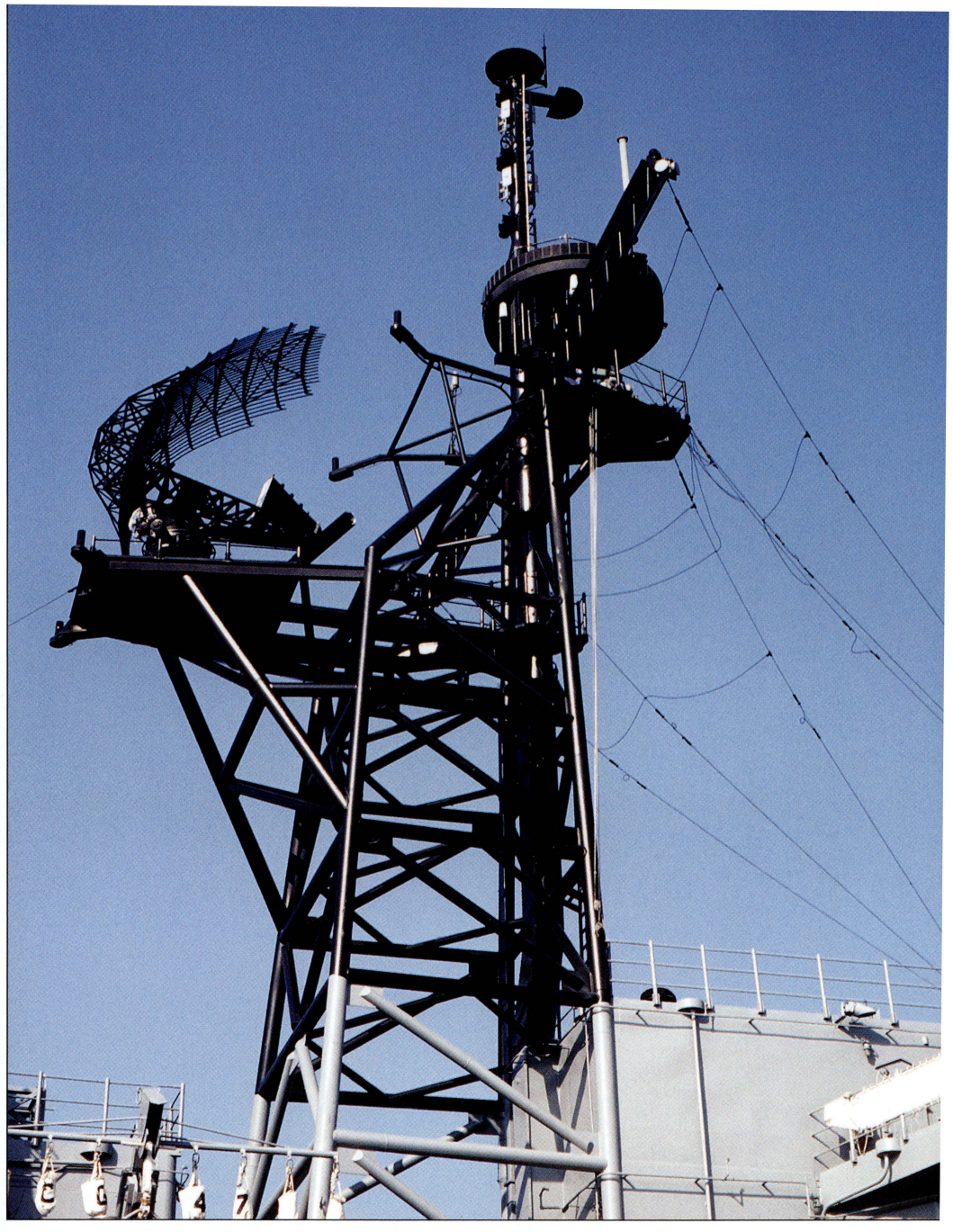
Ships named after battles of the World War II include CG-55 *Leyte Gulf*, CG-60 *Normandy* and CG-68 *Anzio*.

The Battle of Leyte Gulf in the Philippines is possibly the largest naval battle in history. It was a decisive victory for the Allies and a crippling blow to Japan. The Battle of Normandy is the largest amphibious invasion in history when Western Allies assaulted the northern coast of France. The Battle of Anzio established a southern European foothold for the Allies in Italy and forced Germany to fight on another front.

*Thomas S. Gates* (CG-51) is named after a former Secretary of Defense and of the Navy. USS *Chosin* (CG-65) and *Hué City* (CG-66) had name changes. *Shiloh* (CG-65) changed to *Chosin* while CG-66 changed from *Chosin* to *Hué City*. USS *Vicksburg* (CG-69) while under construction had its name changed from *Port Royal* to *Vicksburg*.

Early criticism of the ships as they entered service related to a top-heavy balance and of an apparent lack of armament compared to Soviet-fleet vessels, which were seen to be well endowed with missiles and guns. After rigorous sea trials of weapon systems and maneuver exercises, the ships soon proved their abilities at sea and also in their capacity to store internally and launch a large amount of weapons and control them as they intercepted multiple targets. With the Aegis system, hundreds of targets could be tracked with more than four engaged simultaneously.

***Princeton* (CG-59) and CG-67 *Shiloh* cruise in the Pacific Ocean on 29 March 2008. Both ships have tripod-style main masts with SPS-49 air search radars on large aft-facing platforms. The SPS-49 has a 24-foot-wide reflector and rotates at six or 12 revolutions per minute (rpm). Increased rpm degrades range performance. It provides two-dimensional target data, range and altitude. A jackscrew located behind the reflector adjusts angle to compensate for ship motion. (Kyle D. Gahlau / U.S. Navy)**



**The early design of the *Ticonderoga* mainmast featured four support legs and an SPS-49 air search radar on an aft platform on 5 October 1983. The TACAN is at very top of mast with large circular array below devoted to IFF. The area is painted black to mask its constant exposure to stack exhaust. (Don S. Montgomery / Navy)**

Guided-missile cruiser *Princeton* (CG-59) is underway as an element of Carrier Strike Group 11 in the Pacific Ocean on 29 April 2013. Four RGM-84 Harpoon missile canisters are on its fantail. The black day shapes displayed (a pair of black balls with a diamond shape in the center) from its yardarm indicate to other vessels that this ship is in a condition of restricted maneuvering. (Raul Moreno Jr. / U.S. Navy)

Three *Arleigh Burke*-class destroyers are berthed near CG-68 *Anzio* at Pier 7 in Norfolk on 25 April 2013. The 66-foot-wide beams of the DDG ships are evident when placed near CG-68 *Anzio* with a narrower beam at 55 feet and nearly 60-foot longer hull length. Both classes have Aegis radars and Standard Missiles. (Scott Barnes / U.S. Navy)

*Lake Champlain* (CG-57) refuels from aircraft carrier CVN-76 *Ronald Reagan* in the Indian Ocean on 15 February 2006. CVN-76 is the sixth ship of the improved *Nimitz* class, and weighs 98,235 tons at full load. Length is 1,092 feet overall, draft is 38 feet. Flight deck beam is 252 feet. It carries about 3 million gallons of fuel. (Kathleen Gorby / U.S. Navy)

*Gridley (*DDG-101*),* right, overtakes CG-62 *Chancellorsville*, left, in the Andaman Sea on 27 Sept 2009. The wide beam of the destroyer class contrasts the long, slender hull design of the cruiser. Navy average beam-to-length ratio is 1:9. For DDG destroyers the beam-to-length ratio is 1:7.9, whereas the *Ticonderoga*-class ratio is 1:10.2. Both ships were designed for a specific set of tasks in a hull design best suited for the assigned missions. The cruiser hull is adapted from the *Spruance* hull form. (Joshua Scott / Navy)

**USS *Cowpens* (CG-63) cruises in the Pacific Ocean on 9 September 2012. To the right of the flag are two large exhaust stacks for the engines and a smaller stack for a generator. On the deck to the left of the flag are twin launchers for Mk 234 Nulka hovering decoys. Two Phalanx CIWS units are located aft of the stacks. (Paul Kelly / U.S. Navy)**



## *Ticonderoga*-class Baseline configurations

*Ticonderoga* and CG-48 were built to the Baseline 0 standard. Baseline 0 ships included an Aegis Mk 7 with a SPY-1A radar, weapons control system Mk I, SM-2 MR Block I Standard Missiles, Mk 26 twin-arm missile launchers, Mk 116 Mod 4 underwater fire control system, extended-range 5-inch/62-caliber guns, two SH-2F LAMPS I helicopters (later modified to use SH-60B LAMPS version), and a UYK-7 combat direction system computer. *Ticonderoga* and CG-48 received the SQR-17 sonobuoy processor. *Ticonderoga* and *Yorktown* were the only class ships completed with some lead ballast in the hull.

Baseline 1 was applied to *Vincennes* (CG-49), *Valley Forge* (CG-50) and *Thomas S. Gates* (CG-51). Baseline 1 was composed of an Aegis with improved displays, Mk 26 launchers (each Mod 1 magazine holds 44 Standard Missiles aft, a mix of 24 Standard Missiles/20 ASROC forward), a recovery-assist secure and traverse system (to handle SH-60B Seahawk helicopters in high sea states), SSQ-28 LAMPS Mk III Hawklink data-link (installed high on the main-mast), and an enhanced EW suite.

Baseline 2 was fitted to CG-52 *Bunker Hill* through CG-58 *Philippine Sea* and included the Mk 41 Mod 0 vertical launch system with a SWG-3 ship fire-control system. Vertical launch systems use an assortment of missiles in canisters that are stored vertically for lower power consumption and higher survivability with rapid-fire capability.

Link 11 and UYQ-21 utility data displays were installed. Link 11 is a secure tactical digital information radio link used by NATO for sequential data. It exchanges digital information among sea, air and land-based tactical data systems.

USS *Mobile Bay* (CG-53) and later ships replaced the 26-foot motor whale-boat with a 24-foot rigid-hull inflatable boat. *Antietam* (CG-54) and *Leyte Gulf* (CG-55) installed the SQR-19 TACTAS. *San Jacinto* (CG-56) had the SQQ-89(V)3 integrated antisubmarine warfare suite with SQS-53B sonar, TACTAS and Mk 116 Mod 0 underwater fire control system. All Baseline 2 ships had the theater ballistic missile defense equipment and cooperative engagement capability (CEC) systems interface installed by 2003 at a total cost of $137 million. Upgrades to electronic engineering systems were also completed.

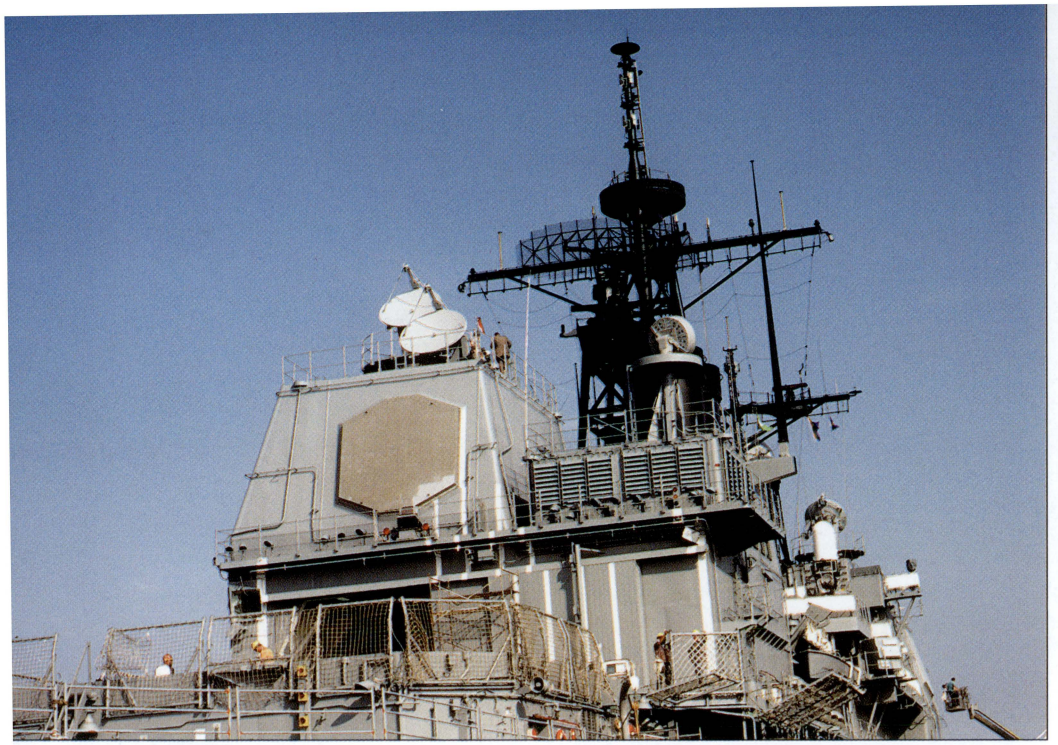
Baseline 3 was applied to CG-59 *Princeton* through CG-64 *Gettysburg*. Baseline 3 includes everything from Baseline 2 plus an SPY-1B Aegis radar system with increased resistance to electronic countermeasures and UYQ-21 display consoles. Baseline 3 also includes new combat direction system computers (UYK-43 and UYK-44).

Baseline 4 (CG-65 to CG-73) added the UYK-43 and UYK-44, and improved UYS-20 display systems. This resulted in an advanced situational awareness in the CIC during tactical scenarios. Previous bow sonars were replaced with the SQS-53C variant. All Baseline 4 ships use the WSN-7 ship navigation ring laser gyro and the utility sonar navigation UQN-4 depth sounder.

USS *Monterey* (CG-61) was the first ship to receive the Baseline 5 phase III equipment upgrade in 1996. Baseline 5 included the Joint Tactical Information Distribution System (JTIDS) Link 16 Mod 5, and the UYK-43 to replace the UYK-7 combat direction system computer. USS *Princeton* (CG-59) and *Gettysburg* (CG-64) updated their combat direction computers. They replaced UYK-21 sets with UYK-70 hardware.

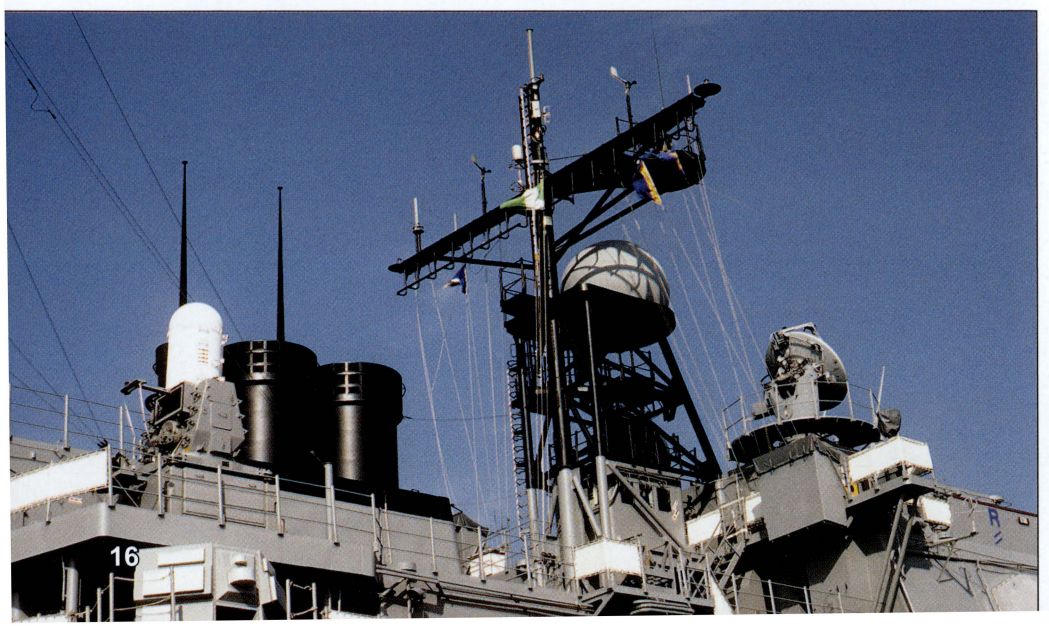
USS *Chosin* (CG-65) departs Sydney Harbor in Australia after a goodwill visit on 11 October 2013. Australia is an important partner and helps maintain stability in the Pacific Ocean region. U.S. Navy ships frequently conduct joint exercises such as Talisman Sabre with the Royal Australian Navy. During such drills, amphibious landings are performed, ships conduct maneuvers at sea, and personnel share and implement ideas on tactics, logistics and re-supply. (Andrew Albin / U.S. Navy)

Guided-missile cruiser *Gettysburg* (CG-64) transits through the Strait of Gibraltar on 3 August 2013. Narrow passages such as this strait are considered to be strategic chokepoints in times of conflict and a challenge to negotiate in peacetime. This clear, daylight scene makes this event seem routine, however darkness, fog, and rough seas make this routine maneuver become one that requires the crew to be focused and alert for navigational hazards or errant ships. (Taylor DiMartino / U.S. Navy)



**The aft deckhouse on *Ticonderoga* features an aft-facing SPY-1A array, two Mk 80 illuminators, and an OE-82 UHF satcom antenna on pedestal on 5 October 1983. Below the Aegis is the open door to the helicopter hangar. (Don S. Montgomery / U.S. Navy)**

**The forward superstructure of CG-47 features CIWS, an early configuration of foremast with a radome for SPQ-9A and the starboard Mk 80 Aegis illuminating radar of which this class of ship carries four on 5 October 1983. (Don S. Montgomery / U.S. Navy)**





# Operational Notes

From August to November 1987, CG-52 *Bunker Hill* operated in the northern Arabian Sea and Gulf of Oman. It escorted and supported 10 Operation Earnest Will convoys.

In July of 1988, while on alert from Iranian attacks in the Persian Gulf by small boats that had fired on a helicopter, CG-49 *Vincennes* fired two SM-2 MR Standard Missiles from the forward Mk 26 launcher at what was believed to be a hostile aircraft. It was actually an Iran Air Airbus A300 civilian airliner. The investigation later revealed that the crew on *Vincennes* mistakenly identified the A300 as an Iranian F-14 Tomcat fighter. The U.S. Government acknowledged the loss of lives but did not apologize for the incident. A financial settlement was later reached with relatives of the 290 victims.

In June of 1990, CG-57 *Lake Champlain* was the first ship to launch an AGM-84E SLAM (stand-off land attack missile) at the Pacific Missile Test Center (PMTC) range.

During Operation Desert Storm in January 1991, seven *Ticonderoga*-class vessels fired cruise missiles at targets in Iraq:

CG-52 *Bunker Hill* fired 28 missiles.
CG-53 *Mobile Bay* fired 22 missiles.
CG-55 *Leyte Gulf* fired 2 missiles.
CG-56 *San Jacinto* fired 14 missiles, which included the first Tomahawk salvoes.
CG-58 *Philippine Sea* fired 10 missiles.
CG-59 *Princeton* fired 3 missiles.
CG-60 *Normandy* fired 26 missiles on its maiden cruise.

On 18 February 1991, *Princeton* (CG-59) was damaged by the detonation of an Italian-made Manta MN103 bottom-mounted influence mine while on patrol 28 miles from Failaka Island of Kuwait in the Persian Gulf. The initial explosion set off another nearby mine. Damage sustained included cracks in the superstructure and three buckled lines in the hull. The port rudder was jammed, the No. 3 switchboard section was flooded due to burst pipes, and damage was incurred to the starboard propeller shaft. In spite of this damage, the ship was able to maintain combat status shortly after the mine incident. It was escorted out of the mine field and after temporary repairs in Bahrain and Dubai, *Princeton* cruised home on its own power to finish repair work.

While CG-53 *Mobile Bay* acted as the surface warfare air control unit in the northern Arabian Gulf in March of 1991, it detected and directed carrier-launched attack aircraft to destroy 38 Iraqi naval vessels. The Iraqi navy did not rebuild before the Gulf War.

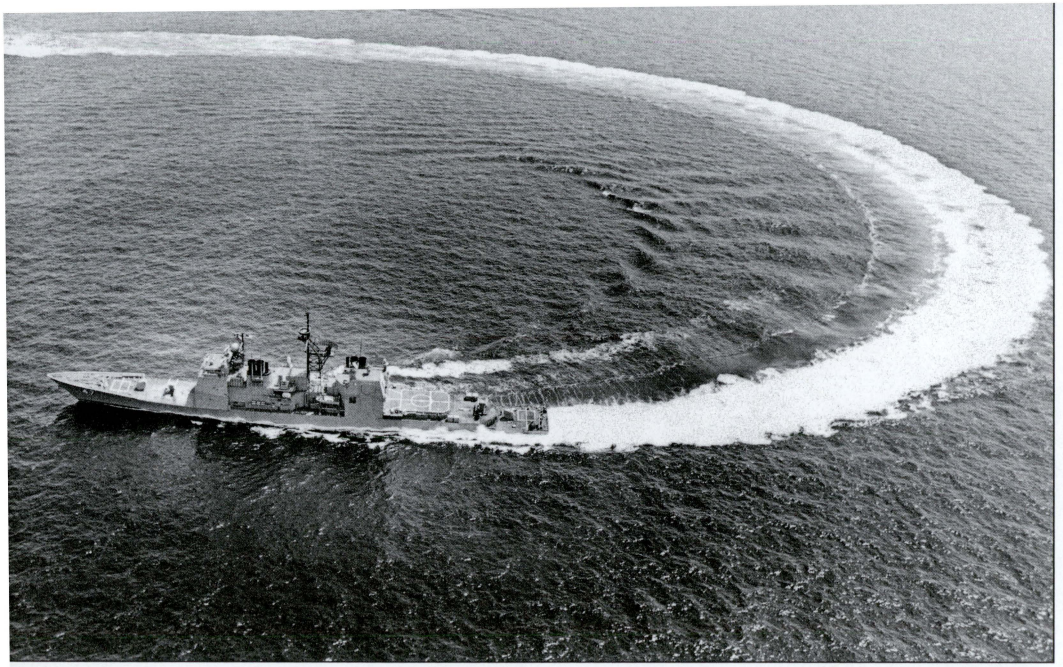
In August of 1991, CG-62 *Chancellorsville* collided with replenishment oiler USNS *Ponchatoula* (T-AO 146) during a night underway replenishment. Both ships were damaged and repaired.

After an assassination attempt on former President George H.W. Bush in June 1993, CG-62 *Chancellorsville* fired nine Tomahawk missiles at the Iraqi intelligence center in Baghdad.

In the fall of 1993, *Leyte Gulf* intercepted 10 tons of cocaine in the Caribbean Sea.

In May 1994, CG-56 *San Jacinto* was at sea for 69 consecutive days while it enforced a no-fly-zone over Bosnia-Herzegovina.

USS *Lake Champlain* (CG-57) is underway with other ships during the annual Rim of the Pacific 2014 exercises on 25 July 2014. Aft of the 5-inch gun is the forward VLS (vertical launch system), which contains 61 missiles of various types. On the top of the foremast is an AS-420 communications intelligence antenna with a pair of AS-1735 UHF wrap-around antennas below. A navigation radar is attached to the starboard yardarm. The area above the bridge windows has a white commercial navigation radar. A pair of high-frequency whip antennas flank the navigation radar. A round AS-3018 UHF satcom "trash can" antenna is in front of one of the pair of AS-3444 Aegis fire control radars. On a pedestal inside a protective radome between the Aegis radars is the AS-4294 USC-38 extra-high frequency (EHF) satcom antenna. Just behind the radome is an SPQ-9B X-band radar used for improved detection of low-altitude cruise missiles. The mainmast has an AS-3240 TACAN antenna at the very top. Below the TACAN antenna is an AS-4127 JTIDS antenna. Below the JTIDS antenna are the cooperative engagement capability (CEC) four-element planar array active antennas. A nearby platform below has an AS-3134 64-element IFF array surrounding the AS-3274 LAMPS helicopter data-link antenna radome. SAT-2 ship infrared blinkers are located at both ends of the yardarms. (Shannon Renfroe / U.S. Navy)



**Guided-missile cruiser *Ticonderoga* (CG-47) executes a tight, high-speed 180-degree turn in the Gulf of Mexico on 1 August 1982. (U.S. Navy)**

***Vella Gulf* (CG-72) sails at speed while attached to Landing Helicopter Dock (LHD) 7 *Iwo Jima* expeditionary strike group during a composite unit training exercise in the Atlantic Ocean on 13 July 2008. (Daniel A. Taylor / U.S. Navy)**

In November of 1994, CG-64 *Gettysburg* and FFG-40 *Halyburton* responded to a distress call from the *Achille Lauro* cruise liner, which was on fire 130 miles east of Somalia. The two ships rescued 800 passengers and took them to Djibouti to disembark.

During late spring of 1995, CG-57 *Lake Champlain* escorted the *Constellation*, *Lincoln* and *Theodore Roosevelt* carrier battle groups for 82 days and also conducted maritime intercept operations in the Persian Gulf region.

In August 1995, CG-60 *Normandy* fired 13 Tomahawks at targets in Bosnia-Herzegovina during Operation Deliberate Force.

In October 1995, CVN-71 *Theodore Roosevelt* suddenly slowed its forward speed as CG-55 *Leyte Gulf* followed behind it. A collision ensued and damaged both ships.

In July of 1997, CG-61 *Monterey* undertook the first test launch of the advanced Tomahawk weapons control system during a live-fire event in the Gulf of Mexico.

In the spring of 1998, the Aegis Baseline 6.1 and CEC 2.0 integration on CG-69 *Vicksburg* suffered serious malfunctions during a test. This malfunction caused cancelation of its deployment while computer program changes and further tests ensued.

In December of 1998, CG-64 *Gettysburg* fired 69 Tomahawks at Iraqi targets during Operation Desert Fox, a four-day bomb campaign that killed 1,400 Republican Guards.

In January of 1999, CG-72 *Vella Gulf* had won the Battle-E for five consecutive years.

In the year 2000, CG-61 *Monterey* was modified to be the test platform for the "Smart Ship" concept. Around 800 changes were made to reduce crew task specialties while new computers and automated navigation systems were installed. The upgrade cost around $8 million. The anticipated savings was $3 million per year after the upgrades to each ship. USS *Mobile Bay* (CG-53) and CG-54 *Antietam* were also converted in late 2000. CG-58 *Philippine Sea* and CG-61 *Monterey* were chosen in 2001 to explore ship operations with reduced crew numbers as a continuation of the "Smart Ship" concept.

In the summer of 2000, CG-73 *Port Royal* visited the port of Durban in South Africa. The visit was the first by a U.S. Navy warship in 25 years. An estimated 10,000 guests came aboard during a series of public tours to view the ship and interact with its crew.

During the spring of 2001, CG-63 *Cowpens* was one of 97 ships from 30 nations as the U.S. Navy representative at the 2001 International Fleet Review.

In October of 2001, CG-58 *Philippine Sea* fired Tomahawks against al-Qâ'idah (al-Qaeda) and Taliban targets in Afghanistan as part of the start of the War in Afghanistan in response to terror attacks on the World Trade Center on 11 September 2001.

In November of 2001, CG-54 *Antietam* provided air cover for the World Trade Organization meeting in Qatar.

In December 2001, CG-53 *Mobile Bay* with a U.S. Coast Guard law enforcement detachment aboard seized 10.5 tons of cocaine 800 miles southwest of Acapulco, Mexico.

While in the Persian Gulf from January to April of 2002, CG-57 *Lake Champlain* conducted 135 vessel-boarding search-and-seizure operations, 200 Operation Gulf Sentry missions, and 500 hours of flight operations with naval forces of several nations.

In April 2002, CG-66 *Hué City* fired hundreds of 5-inch rounds on coastal hard targets during the Marine Expeditionary Unit Exercise 2002, held in Djibouti, Africa.

In March of 2002, CG-72 *Vella Gulf* intercepted the merchant vessel (M/V) *Lina*, of undetermined registry, which had evaded previous attempts to stop it. On board was a

cargo of smuggled Iraqi oil.

During a monsoon with 20-foot-high waves off the coast of Oman in June 2002, CG-69 *Vicksburg* and its embarked helicopter detachment, "Proud Warrior," aided the crew of the *Al-Murtada*, which had been adrift for 11 days without propulsion or electrical power.

Also in June 2002, CG-65 *Chosin* returned to sea duty after galley, fire-fighting system, and forward superstructure modifications.

During the initial invasion of the Iraq War, CG-63 *Cowpens* fired 39 Tomahawks.

In September 2003, *Cowpens* and guided missile frigate *Vandegrift* (FFG-48) visited the Chinese navy's South Sea Fleet headquarters for the first time in the port of Zhanjiang.

In March of 2004, CG-58 *Philippine Sea* conducted 210 vessel boarding search-and-seizure operations, supported Operations Enduring Force and Iraqi Freedom, protected the Al-Basrah Oil Terminal and intercepted two dhows containing two tons of drugs, the occupants of which had ties to terrorist groups.

In May 2005, CG-71 *Cape St. George* became the first ship of the class to use the Electronic Chart Display and Information System, which is a paperless network that provides continuous position and navigational safety information for the combat information center, bridge and captain's quarters.

In March of 2006, CG-63 *Cowpens* and CG-65 *Chosin* undertook passing exercises with the Russian Federation Navy warships, which included the destroyer *Marshal Shaposhnikov* (DD 643), the transport landing ship *Nikolay Korsakov* (LST 077) and the Poland-built *Dubna*-class oiler replenishment ship *Pechenga* (AOR 244).

On 14 December 2006, a National Reconnaissance Office satellite was launched by a Delta II rocket from Vandenberg Air Force Base in California. It malfunctioned shortly after it reached orbit and failed to establish ground communications. It was predicted to eventually reenter the Earth's atmosphere. The satellite became known as USA-193. It was a top-secret radar intelligence-gathering platform of 5,000 pounds with a length of 15 feet and width of eight feet. If it had deployed its radar antenna successfully it would have covered an area equivalent to the size of a basketball court. On board the satellite were the compounds hydrazine and beryllium. U.S. officials claimed both compounds were in sufficient quantities to possibly cause exposure hazards to humans if those materials were released by atmospheric friction and scattered over a wide area. Consequently, President George W. Bush authorized the Navy to hit and break up the spacecraft into smaller pieces to burn harmlessly during reentry and avoid danger in the atmosphere.

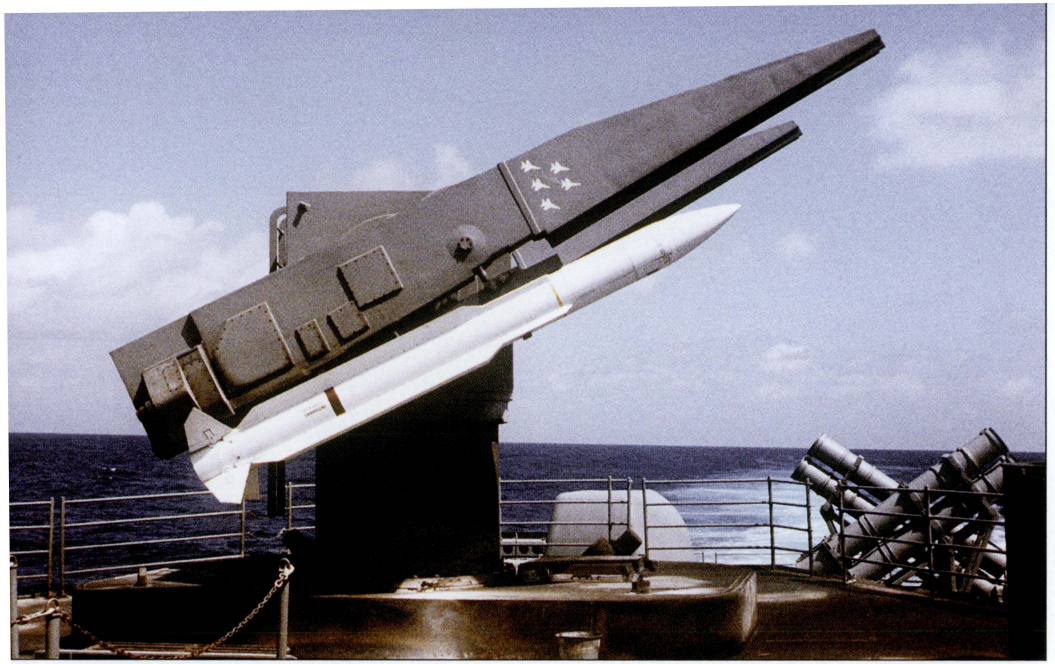
On 21 February 2008, at 03:26 GMT, a single SM-3 Standard Missile was fired from CG-70 *Lake Erie*. At an altitude of 133 miles above the Pacific Ocean, the intercept occurred as the satellite traveled at 17,000 mph. Impact velocity was 22,000 mph and the objective was accomplished.

In February of 2009, CG-52 *Bunker Hill* tested a new Aegis weapon system, CEC and SPQ-9B radar under the Cruiser Modernization Program.

On 9 February 2009, CG-72 *Vella Gulf* captured seven Gulf of Aden pirates after a distress call from M/V *Polaris*. On February 12th, nine more pirates were detained after a distress call from M/V *Prem Divya* of Indian registration.

Also in February of 2009, CG-73 *Port Royal* ran aground near Pearl Harbor. It was eventually floated off the bottom by high tide and 600 tons of weight reduction. Both

**USS *Valley Forge* (CG-50) is overhauled by Southwest Marine Corporation in the floating dry dock *Pride of San Diego* in San Diego on 1 October 1993. (David Gallant / U.S. Navy)**



**RIM-66 MR/SM-2 Standard Missiles stand ready on a Mark 26 launcher before they are fired from *Ticonderoga* (CG-47) during tests near the Atlantic Fleet Weapons Training Facility near Roosevelt Roads in Puerto Rico on 12 March 1983. (Don Muhm / U.S. Navy)**

**An RIM-66 MR/SM-2 Standard Missile fires from the aft launcher aboard the guided-missile cruiser USS *Ticonderoga* (CG-47) on 1 May 1983. (U.S. Navy)**

prop blades were sheared off and the sonar dome was damaged.

In May of 2010, CG-56 *San Jacinto* rescued five Yemeni mariners from 13 suspected pirates aboard the dhow *Al Jawat*, 68 miles southeast of Ra's Fartak, Yemen. Later in the same month, CG-56 *San Jacinto* prevented a pirate attack on the Maltese-flagged M/V *Avenue Beauty* off the coast of Somalia.

In July of 2011, CG-58 *Philippine Sea* rescued 26 Filipino crewmen from Somali pirates and a ship fire aboard the M/V *Mt. Brilliante Virtuoso*. After a hijack attempt by Somali pirates, a superstructure fire broke out on the ship, which carried 1 million barrels of oil from the Ukraine to China.

In June of 2012, CG-59 *Princeton* assisted the Mexican navy to recover 186 bales of marijuana, which were dumped into the sea off the California coastline. The bales of marijuana were then transferred to the U.S. Coast Guard cutter WPB 1313 *Edisto*.

In February of 2013, Secretary of Defence Leon Panetta delayed the deployments of CG-64 *Gettysburg* and CVN-75 *Harry S. Truman* due to anticipated budget shortfalls.

In November of 2013, CG-62 *Chancellorsville* was hit on the port side by a malfunctioning BQM-74 Chukar aerial target drone near California. Two sailors were injured and a three-foot hole was left in the hull. Combat information center and Aegis radar-related equipment were damaged. Repairs took about six months to complete and cost nearly $30 million. The collision resulted from loss of drone control and failure of a safety feature that should have made the drone pass by the ship at a safe distance

**Gunner's Mate 1st Class Robert Lambert maintains canister hatches on guided-missile cruiser *Vella Gulf* (CG-72) in the Atlantic Ocean on 24 July 2008. Twin-arm launchers gave way to the Mk 41 vertical launch system (VLS). Various missiles are stored and ready to fire from canisters protected by hatches. (Chad R. Erdmann / U.S. Navy)**

# Baselines 0 and 1 Configuration

**These five ships with twin-arm Mk 26 missile launchers have. All been decommissioned.**

| Ship | Builder | Laid down | Launched | Service | Decommissioned |
|---|---|---|---|---|---|
| CG-47 *Ticonderoga* | Ingalls | 21 Jan. 80 | 25 April 81 | 22 Jan. 83 | 30 Sept. 04 |
| CG-48 *Yorktown* | Ingalls | 19 Oct. 81 | 17 Jan 83 | 4 July 1984 | 10 Dec. 2004 |
| CG-49 *Vincennes* | Ingalls | 20 Oct. 82 | 14 Jan. 84 | 6 July 1985 | 29 June 05 |
| CG-50 *Valley Forge* | Ingalls | 14 April 83 | 23 June 84 | 11 Jan. 1986 | 30 Aug. 04 |
| CG-51 *Thomas S. Gates* | Bath | 31 Aug. 84 | 14 Dec. 85 | 22 Aug. 87 | 16 Dec. 05 |

# Baselines 2, 3, and 4 Configuration

**Listed below are the Mk 41 vertical launch system-equipped ships. These ships remain on active duty around the globe. All ships will sail beyond their 30-year planned date.**

| Ship | Builder | Laid down | Launched | In service | Fleet |
|---|---|---|---|---|---|
| CG-52 *Bunker Hill* | Ingalls | 11 Jan. 1984 | 11 March 1985 | 20 Sept. 86 | Pacific |
| CG-53 *Mobile Bay* | Ingalls | 6 June 1984 | 22 Aug. 85 | 21 Feb. 87 | Pacific |
| CG-54 *Antietam* | Ingalls | 15 Nov. 84 | 14 Feb. 86 | 6 June 1987 | Pacific |
| CG-55 *Leyte Gulf* | Ingalls | 18 March 85 | 20 June 86 | 26 Sept. 87 | Atlantic |
| CG-56 *San Jacinto* | Ingalls | 22 July 85 | 14 Nov. 86 | 23 Jan. 88 | Atlantic |
| CG-57 *Lake Champlain* | Ingalls | 3 March 1986 | 3 April 1987 | 12 Aug. 1988 | Pacific |
| CG-58 *Philippine Sea* | Bath | 8 May 1986 | 25 April 87 | 18 March 89 | Atlantic |
| CG-59 *Princeton* | Ingalls | 15 Oct. 86 | 2 Oct. 1987 | 11 Feb. 1989 | Pacific |
| CG-60 *Normandy* | Bath | 7 April 1987 | 19 March 88 | 9 Dec. 1989 | Atlantic |
| CG-61 *Monterey* | Bath | 19 Aug. 87 | 22 Oct. 88 | 16 June 90 | Atlantic |
| CG-62 *Chancellorsville* | Ingalls | 24 June 87 | 15 July 88 | 4 Nov. 1989 | Pacific |
| CG-63 *Cowpens* | Bath | 23 Dec. 87 | 11 March 1989 | 9 March 1991 | Pacific |
| CG-64 *Gettysburg* | Bath | 17 Aug. 88 | 22 July 89 | 22 June 91 | Atlantic |
| CG-65 *Chosin* (ex-*Shiloh*) | Ingalls | 22 July 88 | 1 Sept. 1989 | 12 Jan. 1991 | Pacific |
| CG-66 *Hué City* (ex-*Chosin*) | Ingalls | 20 Feb. 89 | 1 June 1990 | 14 Sept. 91 | Atlantic |
| CG-67 *Shiloh* | Bath | 1 Aug. 1989 | 14 July 90 | 18 July 92 | Pacific |
| CG-68 *Anzio* | Ingalls | 21 Aug. 89 | 2 Nov. 1990 | 2 May 1992 | Atlantic |
| CG-69 *Vicksburg* (ex-*Port Royal*) | Ingalls | 30 May 90 | 2 Aug. 1991 | 14 Nov. 92 | Atlantic |
| CG-70 *Lake Erie* | Bath | 14 March 90 | 13 July 91 | 24 July 93 | Pacific |
| CG-71 Cape St. George | Ingalls | 19 Nov. 90 | 10 Jan. 1992 | 12 June 1993 | Pacific |
| CG-72 *Vella Gulf* | Ingalls | 22 April 91 | 13 June 92 | 18 Sept. 93 | Atlantic |
| CG-73 *Port Royal* | Ingalls | 18 Oct. 91 | 20 Nov. 92 | 30 April 94 | Pacific |

As *Ticonderoga* maintains a steady course, a Standard Missile takes to the air from a Mk 26 launch rail in the Atlantic Ocean on 4 April 1983. The missile will sense and home in on radiation emitted from an Aegis Mk 80 illuminator. (Bruce Trombecky / U.S. Navy)

USS *Bunker Hill* (CG-52) sails alongside T-AO 193 *Walter S. Diehl* during a replenishment at sea operation in the Gulf of Oman on 14 April 2015. (Eric Coffer / U.S. Navy)

USS *Vella Gulf* (CG-72) maneuvers to avoid a torpedo during an exercise in the Indian Ocean on 7 December 2008. Streamed from its transom is an SLQ-25 Nixie torpedo countermeasures device that creates ship noises to lure wake-homing, active and passive weapons away from the ship. (Jason R. Zalasky / U.S. Navy)

USS *Mobile Bay* (CG-53) cuts through the water during a high speed run in the northern Arabian Sea on 4 September 2006. These ships appear top-heavy. Many ships are now close to the structural weight limit. The Cruiser Modernization Program incorporates many weight-reduction measures. (Justin R. Blake / U.S. Navy)

After a refuel from the nuclear aircraft carrier CVN-76 *Ronald Reagan*, cruiser CG-57 *Lake Champlain* performs a breakaway maneuver. Its bow bites into the calm waters of the Pacific Ocean on 6 February 2007. The starboard SLQ-32 electronic warfare array keeps a level orientation as the ship leans to port. (Joshua Scott / U.S. Navy)

USS *Monterey* (CG-61) keeps station (maintains relative position to another moving vessel) at high speed while in the Arabian Gulf on 3 June 2013. The ship has many satellite communication systems radomes, and four RGM-84 Harpoon canisters aft. The ships include a few radar cross-section design features. (Billy Ho / U.S. Navy)

# Ballistic Missile Defense Milestones

The following is a review of some events in the development of a sea-borne BMD capability. These milestones were largely undertaken by CG-70 *Lake Erie*:

- July 2000 – fired prototype SM-3 and engaged ballistic missile dynamic test track that was generated and displayed into the Aegis lightweight exo-atmospheric intercept system.
- January 2001 – fired prototype SM-3 flight test round to prove 3rd-stage stability and control, which included a 4th-stage warhead separation event.
- January 2002 – successfully hit an Aries target missile with an SM-3.
- September 2002 – tracked intercontinental ballistic missile with an SPY-1 in the Glory Boost (GB-108) event.
- November 2002 – second interception of an Aries target missile with a SM-3.
- June 2003 – fired an SM-3 Block 0 that failed to hit the target.
- December 2003 – tracked, engaged and destroyed an Aries missile target with an SM-3 Block 0 at 137km altitude.
- February 2005 – destroyed Aries target missile with an SM-3 Block 1A.
- November 2005 – fired an SM-3 Block 1A at a simulated medium-range ballistic missile that deployed a warhead stage.
- March 2006 – fired an SM-3 Block 1A during an Missile Defense Agency and Japan self-defense agency cooperative flight test. Missile had a Japanese-designed nose-cone of advanced materials and Aegis BMD weapon system.
- May 2006 – intercepted a short-range ballistic missile (SRBM) target for the first time in its final seconds of flight – known as the terminal phase.
- April 2007 – simultaneously fired an SM-3 Block 1A that hit a target at 100 miles altitude, while an SM-2 Block IIIA was fired at an air-launched hostile target, in a demonstration of the warship's ability to defend itself while undertaking exo-atmospheric engagements in a short period of time.
- November 2007 – The Pacific Missile Test Range Facility launched two SRBM target missiles within seconds of each other. USS *Lake Erie* (CG-70) hit both at 100 miles altitude using 2 SM-3 Block IV missiles.
- June 2008 – fired two SM-2 Block IV missiles as part of Flight Test Mission 14 and hit a 12-mile-high target SRBM.
- September 2011 – an SM-3 Block IB failed to hit a target SRBM.
- May 2012 – fired an SM-3 Block IB and then guided it for a hit on an SRBM target by using the Aegis 4.0.1 weapon system.
- June 2012 – fired an SM-3 Block IB and hit its target.
- February 2013 – SRBM was launched from Pacific Missile Test Range Facility. Five minutes later, an SM-3 Block IB was fired using the in-orbit space tracking and surveillance system demonstrators to successfully hit the target missile.
- May 2013 – SRBM target was fired. Two minutes later, an SM-3 Block IB hit the target missile.
- September 2013 – Pacific Missile Test Range Facility launched a single SRBM target missile downrange. *Lake Erie* fired two SM-3 Block 1-B missiles and hit the target.

**CG-70 *Lake Erie* fires a Standard Missile SM-3 Block 1B from its forward VLS module at a short-range ballistic missile (SRBM) target as the ship cruises in the Pacific Ocean during a Missile Defense Agency live-fire test on 18 September 2013. The target was successfully hit. Remote cameras were bolted to the deck to record the launch because the entire deck area is cleared of crew members during the VLS launches. (DOD)**

*Lake Erie* fires an SM-3 at a missile target from its vertical launch system (VLS) in the Pacific Ocean on 18 September 2013. The steel outer hatch opens before launch. The missile exits through the canister and pushes through a frangible panel. The long slender exhaust hatch opens to vent the heat and flames out of the VLS compartment. If a fire starts in the VLS itself, an installed system would activate to cool nearby canisters. If fire suppression fails, the entire module can be flooded with water. (DOD)

An SM-2 Standard Missile is displayed at the White Sands Missile Range in New Mexico on 23 March 2011. A blue band at aft section indicates an inert rocket motor. Design of this weapon began in 1963. The name Standard Missile was used because this type replaced three older missiles called Tartar, Terrier and Talos. Lessons learned and technology advances resulted in this capable, fast and adaptable model in many variants. Some have extended range and others are used to intercept ballistic missiles. (Author)

## Post-Production Modification

Baseline 3 ships got the SPY-1D radar to improve functions in littoral regions as well as new combat systems computers, consoles and displays. CEC, theater ballistic missile defense and new Standard Missiles can be integrated with these additions. Vertical launch system loading cranes were removed. Consequently, six more missiles (three per module) were added. The torpedo recognition and alertment functional segment, an enhancement to the SQQ-89 sonar, was installed on all ships.

Satellite communications antennas were upgraded for new capabilities. A larger USC-38 dish antenna and increased capacity equipment was added to allow more message traffic in the extra-high frequency bandwidth. Operating in gigahertz frequencies, these systems are less prone to be jammed and are incorporated into the Milstar satellite constellation in geostationary orbit. Antenna size is kept to a minimum and the system exhibits increased anti-jamming characteristics. A WSC-6 satcom antenna was added to the topside (in two large radomes) to provide super-high frequency communication with defense satellite system space-based platforms. It is an arrangement of one radome forward above the bridge and one on the aft deckhouse. Access to this satellite constellation increases inter-service operability. High-gain antennas with narrow beamwidths were used because they are less likely to be detected or jammed. High data exchange rates are also accomplished.

An IT-21 (information technology for the 21st century) radome is located forward of the mainmast and is used to optimize onboard equipment with satellite communication services. The JTIDS AS-4127A truncated collar antenna, which operates at 925 to 1215 megahertz, was installed on the mainmast below the TACAN. JTIDS offers users full access to tactical situations, such as surveillance data, fighter aircraft links and voice channel information sharing as events unfold.

All ships received the Mk 234 Nulka hovering decoy, which lures anti-ship missiles away from the intended target. A pair of two-round launchers are located on the port side. They are located near the CIWS beside the Marisat radome. On the starboard side, a second pair of decoy launchers are placed on the forward deckhouse. Each Nulka decoy round is 78.7 inches long, has a diameter of 7.9 inches, and weighs 148.8 pounds. Several can be launched to counter multiple anti-ship missile threats simultaneously. The RUM-139 vertical launch ASROC was added to VLS to provide a launch capability the Mk 46 torpedo and quickly get the round to the vicinity of a submarine contact. Phalanx CIWS were upgraded. An electro-optical sensor imager was added to the Phalanx unit to view and record scenes as well as provide better in-close engagement accuracy.

AS-145 high-frequency loop monopole direction-finding closed-loop antennas are sited around the superstructure. An enhanced AS-420 UHF/VHF communications intelligence antenna array improves direction-finding collection and analysis. Some ships also installed an advanced array enclosed in a round tapered housing.

Other antenna upgrades include the HK014 UHF/VHF di-pole antenna unit, the AS-179 log periodic di-pole array and the AS-180 tapered-slot antenna with a PST-61D-MIL positioner to adjust the angle of both the AS-179 and the AS-180 aerials. All are located along the sides of the superstructure.

**An HH-60H Seahawk of the HS-5 "Night Dippers" delivers cargo to CG-68 *Anzio* as it cruises in the Mediterranean Sea on 20 October 2006. The ship's aft 5-inch gun is turned to port. (Miguel Angel Contreras / U.S. Navy)**

Seaman Apprentice Todd McBurnett Jr., left, hoses mud off the bow anchor chain of CG-68 *Anzio* after a port visit to the Seychelles on 22 August 2011. (Brian M. Brooks / Navy)

## Cruiser Modernization Program

At a cost of $220 million per ship (in 2008 dollars), the cruiser modernization program is a comprehensive overhaul. It includes hull, mechanical, electrical, and combat systems, which will bring all of the previously mentioned Baseline-standard ships up to a common tactical configuration. The 22 ships to be modernized are CG-52 through CG-73. The first ship to be overhauled was CG-52 *Bunker Hill*. Work takes about one year to complete per vessel and will enable these ships to provide effective warfighting capabilities today and into the mid 2020s.

Two ships were modernized in both 2009 and 2010, while one more was updated 2011. Beginning in 2012, three ships were modernized per year. As of the fiscal year 2017 budget, seven ships remained. Navy planners want all remaining ships to be completed within the year. The ballistic missile defense capable ships (four of the five due to undergo this work) must stagger their yard stays to ensure capability is at sea on a continuous basis.

New combat system computers are installed with an "open architecture" package, known as the advanced capability build 2008 upgrade. This commercial off-the-shelf hardware replaces older weapon-system computers that had differing hardware and machine-dedicated software files. Past upgrades required that all weapon and sensor systems be individually programmed to accommodate new tactics and threat changes.

This new concept keeps the computers separate from the systems they support, so the computers can adapt quicker to handle new threats and be upgraded more efficiently. Tactical data will now be shared faster with all information fed into a common computer network. Systems to be integrated include: an Aegis SPY-1, an SQQ-89(V) 15, an SQR-20 multi-function towed array, an SH-60 / MH-60R data-link, a CIWS, a 5-inch gun, an RGM-84 Harpoon, and a vertical launch system.

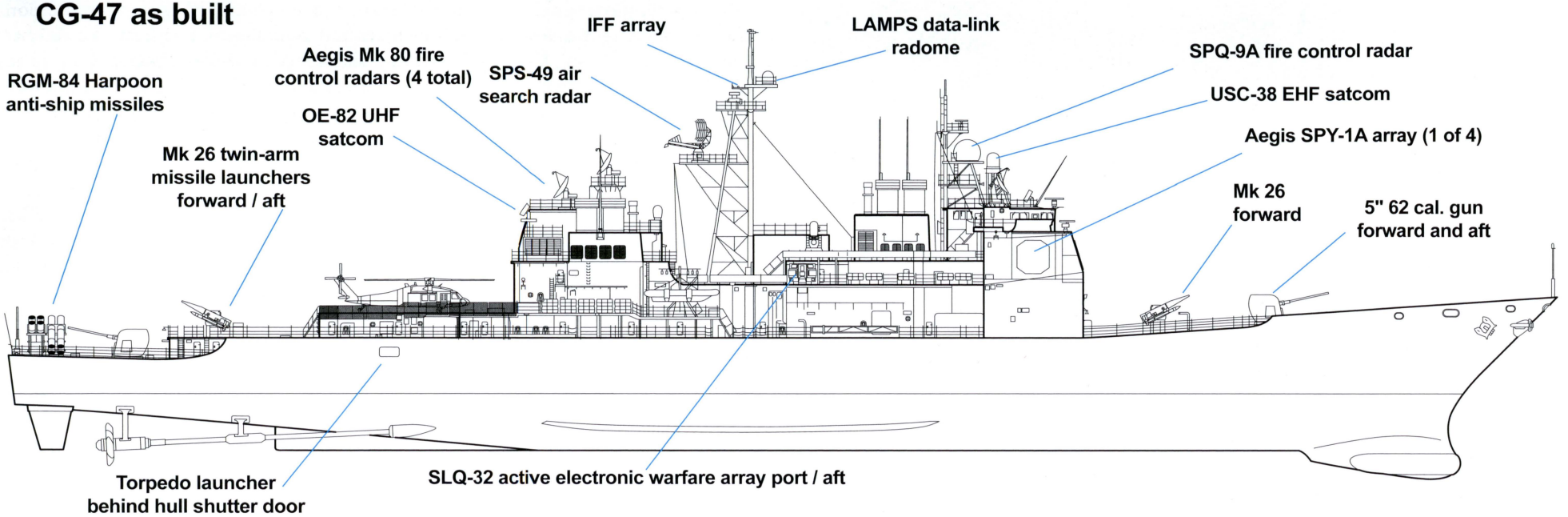
Ships undergoing modernization begin conversion in the dry-dock. The propellers are removed and refurbished. The hull, struts and prop-shafts get a thorough inspection, preservation treatment, new primer and paint. A stern flap set at a fixed angle is installed on the transom below the waterline. The flap improves stability and fuel consumption. Modifications strengthen the hull while all watertight doors and hatches are inspected and updated.

Steam systems inside the hull are removed and replaced with electrically-heated devices to save weight and reduce complexity. A reverse-osmosis water system provides drinking water and replaces steam evaporators. The galley and laundry convert to total electricity.

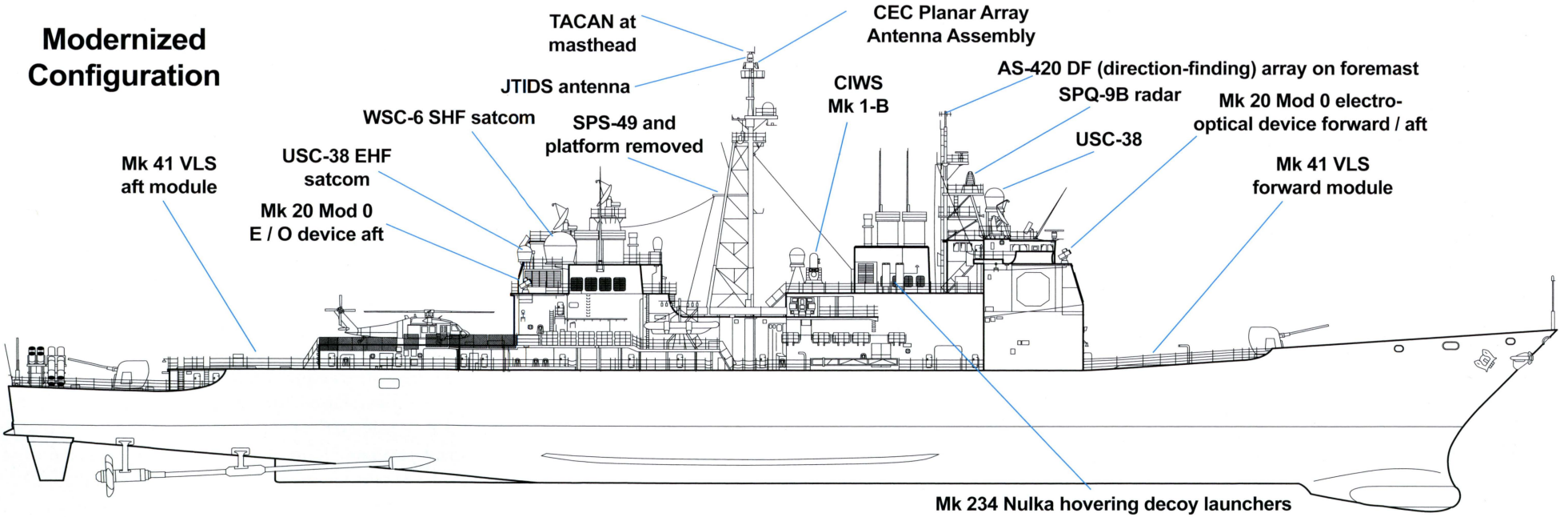
Alterations topside include reduction of the high-profile bow bulwarks to reduce weight. Weight reduction is a major consideration in this series of upgrades as many ships approach the maximum stability margin of 10,200 tons. The Mk 34 gun weapon system and the Mk 45 Mod 2 5-inch/62 caliber gun enhancements are from a new design standard. The Mk 160 gun weapon system is included, which uses data either from the Aegis radars or the Mk 20 Mod 0 electro-optical sights to compute firing solutions. Close in weapon systems Block 1B with optical tracking, infrared optics with reduced side-lobe radar replaces the older Block 1. RIM-162 Evolved Sea Sparrow missiles are included in the VLS load-out with four rounds per canister.

# Cruiser Modernization

## USS *Ticonderoga* CG-47 as built




## Modernized Configuration



**USS *Bunker Hill* (CG-52) VLS cells are installed during its construction at the Ingalls Shipbuilding facility in Pascagoula on 15 April 1985. (Ingalls Shipbuilding / USN)**

Vertical launch systems can also fire the RIM-174 Standard Missile extended range active missile or SM-6. This missile is effective against all aircraft, cruise missiles and unmanned aerial vehicles (drones). The seeker head is adapted from the AIM-120C advanced medium-range air-to-air missile and has a range of 130 nautical miles. Unit cost in 2013 was $4.3 million each with a planned production run of 1,200 missiles.

The AN/USG-2(V) Cooperative Engagement Transmission Processing Set has a lighter array of four planar array antenna assembly units. It replaced the heavy AS-4460 doughnut-shaped antenna. The WSN-8A digital electromagnetic log system provides more accurate speed-over-water and speed-over-ground readings via doppler sensor technology. Weather sensor upgrades include a new digital wind system exterior components as well as new bridge displays to replace the type F windbird sensors.

Two Mk 20 Mod 0 electro-optical sights with laser rangefinders are installed. One sight is located on the port bridge wing while the other is located at the starboard aft corner of the aft deckhouse. The Mk 20 IEU (interface electronics unit) is programmed to allow both sights to feed data to both gun weapons system computers simultaneously. The SPQ-9B radar replaced the SPQ-9A and is in a tapered square radome located on the same platform as the former radar. The SPQ-9B provides increased detection capabilities of inbound anti-ship cruise missiles as they near the horizon.

The SPS-49 air search radar was removed from the mainmast. This change reduced top-side weight by 3,040 pounds and contributed to greater stability. The interior spaces that formerly contained the radar's operating equipment was converted into a crew exercise area. The extra crew space helped to address the complaint of cramped crew spaces on these ships. The SARTIS (shipboard advanced radar target identification system) is installed as well as a fiber-optic network. The SQQ-89(V) 15 sonar suite is an update on Baseline 3 and 4 ships to provide enhanced processing and small object avoidance in shallow littoral waters. These ships also receive the SQR-20 multi-function towed array. High, medium and low transducers are contained within a three-inch diameter cable. The SQR-19 TACTAS winch system is used with the array.

As part of the weapon system upgrades, the Aegis display system OJ-471 console variants of the Q-70 display systems are installed. They have achieved more than 4,500 hours of use in the field without failing and have a reduced height to allow operators to view the large screen displays in the combat information center.

Baseline 2 ships receive the upgraded Mk 116 Mod 7 variant of the anti-submarine warfare fire control system. The common data-link management system increases capability of the command and control processor and allows a human to interface with existing Q-70 consoles. Access to the next-generation Link 11 JTIDS system is included.

In the Fiscal Year 2017 Defense Bill in early 2016, Congress and the Navy agreed on a plan for the refurbishment of cruisers. Once ships are laid up for repairs, they must be returned to the fleet rather than mothballed. Any changes to the plan and ship numbers now requires Congressional approval. The Navy cannot make unilateral decisions on the future status of the ships. Vessels will be completed as shipyards become available with electronics installed last to ensure the latest upgrades are deployed into the fleet.

To further ensure ships would not be taken out of service, a fund in excess of $500 million was set aside to pay for the proposed modernization.

Guided-missile cruiser *Vella Gulf* (CG-72) crashes through waves in the Mediterranean Sea on 28 February 2009. Bow bulwarks are put to good use and show why they are a necessity in such sea states. The aluminum bulwarks were attached the steel hull as the ship was in the process of construction. (Jason R. Zalasky / U.S. Navy)

CG-52 *Bunker Hill* is battered by waves as it approaches CVN-70 *Carl Vinson* for a refueling-at-sea maneuver in the Pacific Ocean on 24 December 2011. Modern warships must be able to withstand such punishment in unforgiving sea conditions to maintain a constant presence the world over. (James R. Evans / U.S. Navy)

Even with bulwarks, water floods the foredeck of CG-63 *Cowpens* as it moves ahead in the Philippine Sea on 26 September 2012. Much effort is devoted to corrosion prevention as sea water is full of minerals that attack steel, aluminum, paint and rubber compounds. The sun and waves take a toll on the hull as well. (Paul Kelly / U.S. Navy)

USS *Chancellorsville* (CG-62) buries its bow into a wave while on patrol in the Arabian Sea on 6 July 2009. It makes ready for a replenishment operation as seen by the Romeo flag on the yardarm. Even in such conditions, refueling or restocking of food and spare parts must be accomplished. (Oliver Cole / U.S. Navy)

***San Jacinto* (CG-56) and CG-58 *Philippine Sea* rest in Souda Bay in Greece on a port visit while assigned to the U.S. 6th Fleet on 14 March 2008. *Philippine Sea* is tied to the pier while *San Jacinto* is rafted alongside. (Paul Farley / U.S. Navy)**

## *Ticonderoga* Replacement

In November of 2011, the replacement program for the next generation cruiser or CG(X) was announced. These ships were to be a class of 19 vessels with ballistic missile defense and area air defense for carrier battle groups. Design was to be similar to the DDG-1000 *Zumwalt*-class destroyer with a displacement of 14,500 tons.

A plan was put forth in 2007 to build five ships to 23,000 tons and dedicated to the ballistic missile defense role. These ships would have nuclear power plants instead of a gas-turbine system. This change was predicted to have advantages due to high oil prices. The construction cost increase of around $600 million to $800 million to install nuclear power was estimated to cost less over time without the need for ship petroleum. However, the idea was dropped due to the cost and time required to acquire long-lead items such as nuclear fuel, which include heavy fissile elements such as uranium-235.

The projected start for the replacements to enter fleet service was in 2017. The fiscal year 2009 budget called for the first ship to begin construction in 2011. The second ship would follow in 2013. The SPY-3 dual-band radar and no gun armament was proposed.

The Obama Administration released a proposed budget for fiscal year 2011 in February of 2010. The budget eliminated the CG(X) entirely. This action was also suggested in the 2010 quadrennial defense review. Later that same year, the program was cancelled outright. The role of CG(X) will be fulfilled by the *Arleigh Burke* Flight III-class destroyer.

**The *Ticonderoga*-class guided-missile cruiser *Chosin* (CG-65) transits the waters of Joint Base Pearl Harbor-Hickam toward the Pacific Ocean on 19 September 2011. *Chosin* conducted exercises off the coast of Hawaii. (Daniel Barker / U.S. Navy)**

**Al Basrah Oil Terminal is patrolled by CG-53 *Mobile Bay* during Operation Iraqi Freedom in the Arabian Gulf on 20 October 2004. Such a show of force can often be enough to deter aggression and attacks on vital installations. (Samuel W. Shavers / U.S. Navy)**

Guided-missile cruiser *Bunker Hill* (CG-52) passes under the Golden Gate Bridge in San Francisco to join sea maneuvers with the Russian Federation Navy cruiser *Varyag* in June 2010. *Bunker Hill* has homeported in San Diego since it shifted from Yokosuka, Japan, in July 1998. (Erik Reynolds / U.S. Navy)

**The crew of CG-62 *Chancellorsville* poses for a portrait in Yokosuka, Japan, after it won the "Battle E" for five years in a row on 17 June 2004. The crew was authorized to change the Battle E from white to gold. The ribbons on the bridge wing above the letters denote the ship was awarded the following medals: Top row – Meritorious Unit Commendation. Second row from left to right – Armed Forces Expeditionary ribbon, National Defense ribbon, and Navy E-ribbon (a wreathed E signifies four or more years that this vessel displayed the Battle E award). Bottom row from left to right – Kuwait Liberation ribbon, Sea Service Deployment ribbon, and Southeast Asia Service ribbon. (Navy)**

***Antietam* (CG-54) approaches T-AO 199 *Tippecanoe* for replenishment on 29 February 2016. It displays a Battle E. To its right is a black E to signify maritime warfare. Next is a green E to signify excellence in ship combat information center operations. The blue E denotes best supply department for two years. The Yellow E shows superior performance in the air department for four years. (David Flewellyn / Navy)**

## Command Excellence Awards and Ribbons

Ships assigned to squadrons compete every year to earn the right to display letters and command excellence awards on the bridge wings. Crews are proud and expend much effort to win and retain awards. Letters and colors denote excellence in various departments and seamanship. The most coveted award is the "Battle E," painted white with shadow. It can be twice as large as other awards (50 inches high by 40 inches wide).

Only one ship per squadron can win this award each year. To win the "Battle E" crews must accomplish a rigorous series of exercises to prove skills such as ship handling and tactics, weapons control and employment, and the ability to react effectively and prevail in a myriad of simulated combat mission scenarios.

If a ship fails to win the next year, the letter must be removed. Ships that win the award in consecutive years add a same-color service stripe underneath the letter.

The ships that win awards five years straight will display a gold E with a silver star above the E. They also have the privilege to fly a battle E pennant, which is a blue triangle shape with a yellow circle in the center. The pennant is flown from a halyard. Examples of other letters (25 inches in height/20 inches in width with no shadow) are:

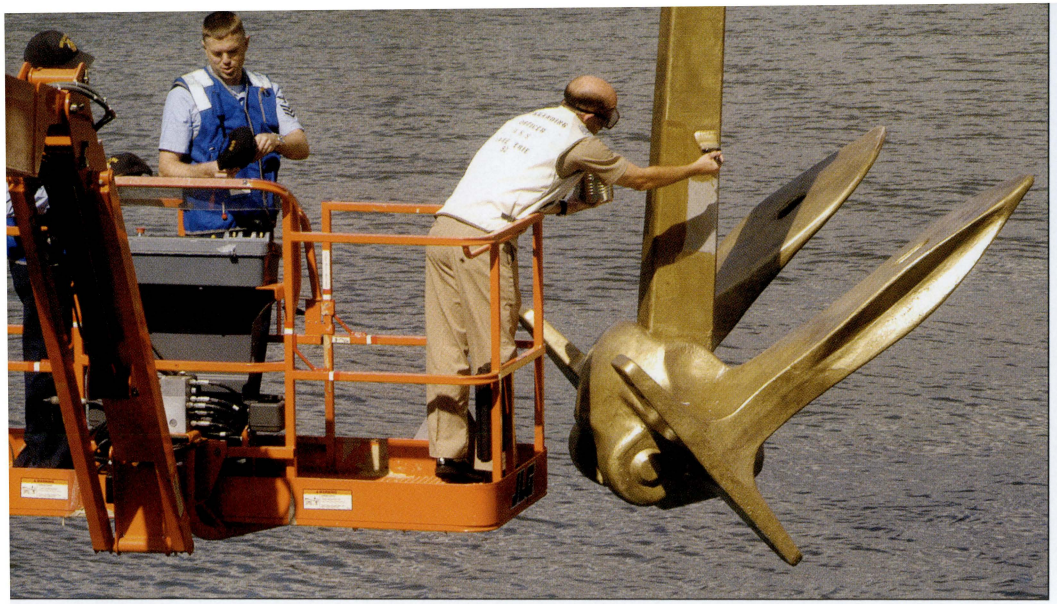
Blue M – awarded for excellence in the medical department.
Red DC – awarded for proficiency in damage control skills.
Blue H – given for best habitability on board.
Red N – Best in navigation skills.
Green C – Won for best communication department.
Red R - Proven to be best at repair operations.
White crossed anchors – Best at deck seamanship.

Aircraft Carriers compete for best air departments (Yellow E) and a black W shows best at weapons department operations. Submarines compete to be the best in anti-submarine warfare (White A), tactical proficiency (White T) and fire control excellence (White F).

Ribbons indicate medals awarded to ships for campaigns or actions in which they participated. Each one is distinctive in color, stripes or overall design. The Kuwait Liberation ribbon is shown in the colors of the flag of the Kingdom of Kuwait. The NATO ribbon is of blue and white, the colors of the North Atlantic Treaty Organization. The United Nations (UN) ribbon is also of blue and white, but the shade of blue in the UN example is of a lighter hue. A UN Service ribbon is an alternating pattern of light blue and white stripes. An Iraq Campaign ribbon consists of a wide center stripe of tan, surrounded on both sides by the colors of the flag of the Republic of Iraq.

Unit Citations such as a Presidential Unit Citation award, a Navy Unit Commendation or a Meritorious Unit Commendation, are displayed as pennants. The Presidential Unit Citation pennant is yellow in the center with blue on the top edge and red along the bottom edge. The Navy Unit Commendation pennant is green in the center with three stripes (blue/yellow/red) along both the top and bottom edges. A Navy Unit Commendation pennant can be seen with a red center surrounded along the top and bottom edges by fields of green with slender stripes of yellow surrounding a blue central stripe.

**USS *Lake Erie* (CG-70) returns to Pearl Harbor after a four-month deployment at sea on 16 June 2014. Its crew mans the rails as the ship makes its approach. It was built at Bath Iron Works with its keel laid down in 1989. It was launched in 1991. It was declared in service in 1993 and assigned to the Pacific Fleet. It is one of a few *Ticonderoga*-class ships involved in ballistic missile defense tests. These test cruisers, along with the *Arleigh Burke*-class of destroyers, have the ability to detect, track and launch missiles against such threats. Modified Standard Missile warheads seek out and hit incoming missiles to disable or destroy them before they can reach their targets. The Aegis radar is also adjusted and optimized for operations in these exo-atmospheric intercept scenarios. This adaptation gave these ships a valuable capability to extend and provide an extra layer of anti-ballistic missile defense options. The ability to fire a missile from a ship in motion into near-space and knock out another missile at great speeds is a monumental technological achievement. This feat combines missile advances such as solid-fuel composition, a seeker able to lock onto and steer precisely towards this target, and a powerful radar able to update and guide the missile throughout the flight profile. Ground-based interceptor missiles are also located at Fort Greeley in Alaska. (Johans Chavarro / U.S. Navy)**



Capt. Scott T. Anhalt, commanding officer of guided-missile cruiser *Lake Erie* (CG-70), applies gold paint onto the stem anchor while in Pearl Harbor, Hawaii, on 8 January 2004. Ships in the fleet that meet crew retention goals for the prior year signify this achievement via the symbolic painting of an anchor. (Johnnie R Robbins / U.S. Navy)

The bow anchor detail of CG-63 *Cowpens* removes chain stoppers as the detail prepares to lower the bow anchor in Shimoda Bay, Japan, on 13 May 2004. A wildcat to the right holds the chain in position. It brings up the chain from the locker below deck and is used to lower and raise the anchor. (Alan Warner / U.S. Navy)

Crewmen watch as CG-57 *Lake Champlain* drops its stem anchor into the waters off the Maldives Islands on 19 February 2009. The stem anchor can be used without damaging the sonar dome, which protrudes ahead of the bow below the waterline. The anchor seen along the starboard side of the hull is used when the stem anchor is not required. The bow bulwarks extend above the steel hull line and have three hawsepipes to pass lines onto the foredeck area. The hull number 57 is in a subdued paint scheme to blend into the gray background. The two small vertical rows of numbers seen below the hull number indicate the present draft while the forward row shows hull draft. The aft-most row of numbers (with the label PROJ) show another 10 feet to the bottom of the sonar dome. (Daniel Barker / U.S. Navy)

# CG-72 *Vella Gulf* Coat of Arms

All warships in the United States Navy have a coat of arms. It is designed by the crew while the ship under construction. All are very colorful, bold and highly symbolic of the ship, its mission and of past vessels that bore the same name. A coat of arms visually illustrates past awards and battles, individuals and a motto associated with the warship. It also features a seal, shield and crest. The following explains the *Vella Gulf* coat of arms.

The seal is a white oval surrounded by a blue collar and enclosed by a gold rope. The blue border has gold letters along the top USS VELLA GULF. The bottom of the border, has CG 72. Blue and Gold are the traditional U.S. Navy colors.

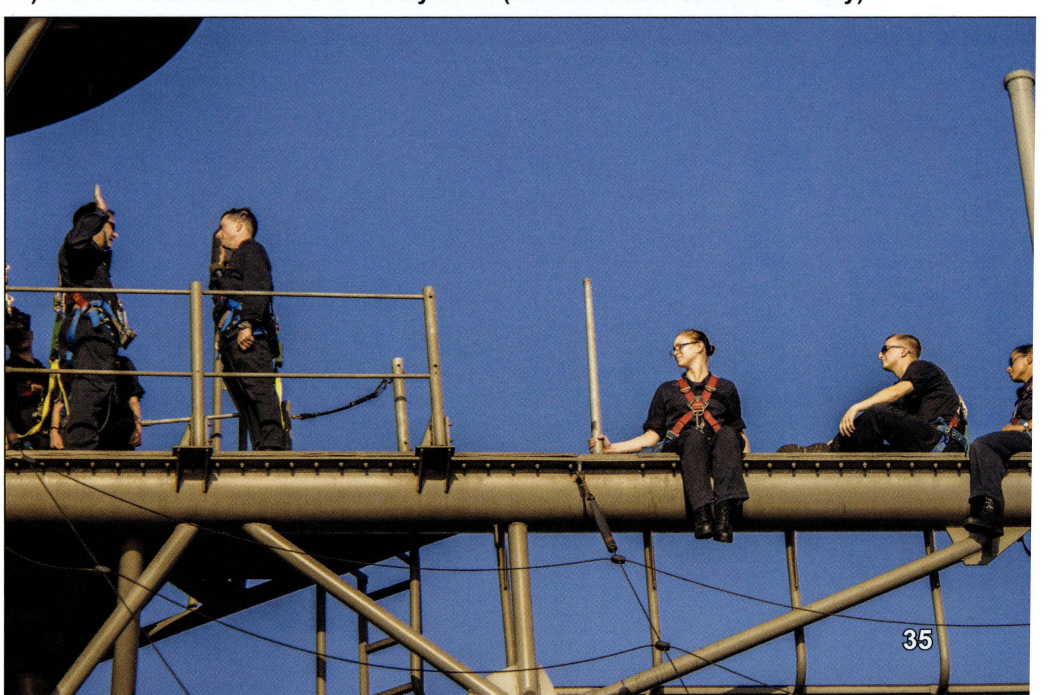
The shield is the traditional Navy dark blue and gold. There are a total of six colored sections on the shield itself. The three blue and three gold shaded areas represent the six U.S. Navy destroyers that were involved in the World War II Battle of Vella Gulf action in the "Slot" that exists in the Solomon Islands chain. The four Japanese destroyers that were defeated in that battle are shown as four red discs. The Slot is represented as two flaunches at either side of the shield. The waves of the open sea are indicated by the wavy line between the red discs and the head of the Eagle. The dark shade of blue used in the shield recalls the hours of darkness, in which this battle was fought. Two swords behind the shield, the "supporters," signify the teamwork and unity of the enlisted and officer corps. The bald eagle in the center of the shield symbolizes the U.S. Navy victory in the Battle of Vella Gulf and of American naval strength in the past and present. The commissioning pennant in the eagle's beak recalls the CVE-111, an escort carrier of the *Commencement Bay* class, that previously had the name of *Vella Gulf*.

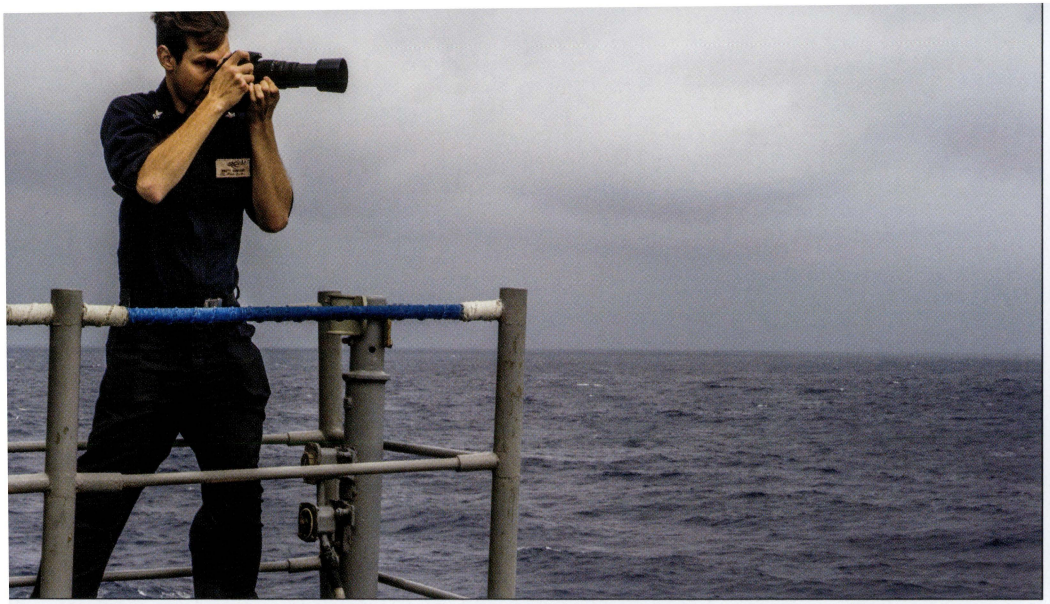
Surrounding the bottom section of the shield is a flowing banner with the words used by General Stonewall Jackson, "MOVE SWIFTLY – STRIKE VIGOROUSLY."

The crest is above the shield consists of a three-pronged trident in gold, which represents the high technology and vertical launch abilities of the Aegis system. Four red lightning flashes signify the quick strike options used in modern naval tactics. The lightning also recalls how radar was used and proved to be an essential element in the Battle of Vella Gulf victory. Red also shows proficiency in the use of weaponry and of crew courage under fire. The single large blue star honors the battle star awarded to CVE-111 *Vella Gulf* for its distinguished fleet service during World War II.

**USS *Vella Gulf* (CG-72) sails at speed during an air power demonstration on 4 March 2002. These ships can reach speeds of 30 knots or more with four LM2500 gas-turbine engines driving two propellers. (Travis Ross / U.S. Navy)**

**Capt. Robert Katz, left, reads the oath of enlistment to Senior Chief Electronics Technician Patrick Cuttle atop the main mast of guided-missile cruiser *Vella Gulf* (CG-72) in the Mediterranean Sea on 1 July 2014. (Edward Gutierrez III / U.S. Navy)**





Information Systems Technician Second Class Brett Armour from Leavittsburg in Ohio uses a digital camera to make a series of photographs of a surface contact from CG-54 *Antietam* in the South China Sea on 1 March 2016. His images will be examined to verify ship type and if any noteworthy changes are evident. (David Flewellyn / U.S. Navy)

Quartermaster Seaman Weston Warr transmits a Morse code message via blinker from CG-54 *Antietam* to DDG-88 *Preble* on 8 August 2013. The light casts a narrow beam. By moving the lever, blades open to emit coded light messages toward another ship. Light signals are a radio-silent means to send communications. (Declan Barnes / U.S. Navy)

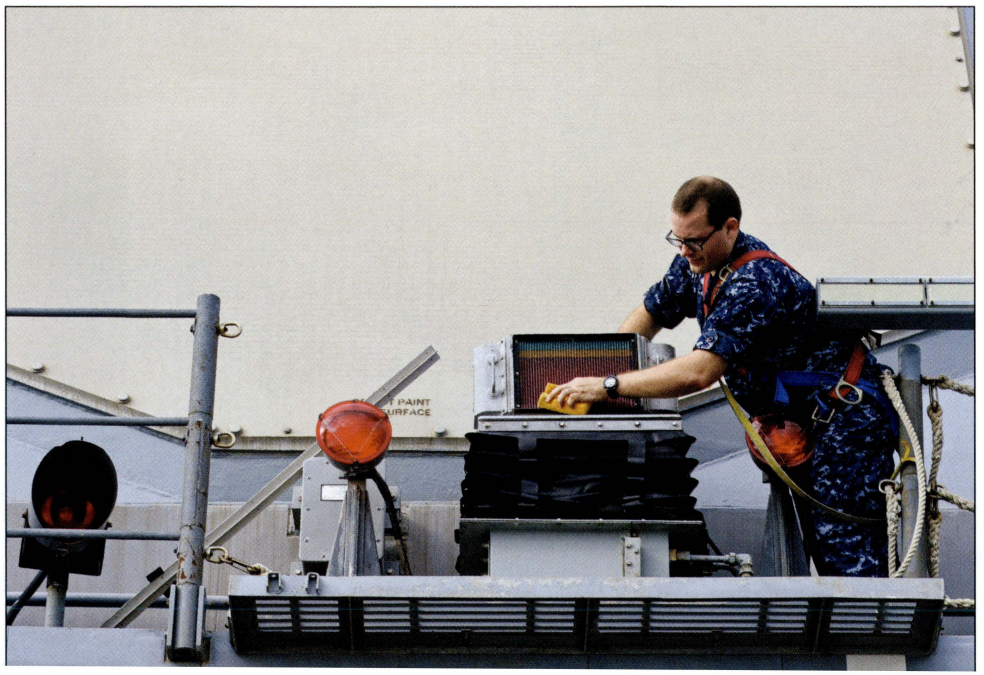
In the spirit of competition and to boost crew morale, teams use fire hoses to push a barrel across a line during a damage control Olympics on CG-52 *Bunker Hill* in the 5th Fleet area of responsibility (AOR). The crew looks forward to such breaks, which provide respite from the routines of duty and training. (Aaron Shelley / U.S. Navy)

Quartermaster Third Class Matthew A. James uses a sextant to obtain a fix while in the Indian Ocean on 5 January 2009. Even with modern Global Positioning System navigation, the old skills are still taught. For sun imaging, various filters are placed in front of the eyepiece. The data will be recorded on paper. (Jason R. Zalasky / U.S. Navy)

The line detail from the crew of CG-62 *Chancellorsville* heaves line during a refueling at sea operation on 28 July 2011 in the Gulf of Aden. The sailors listen for instructions from the detail leader with megaphone in hand. The blue helmets signify that the detail is assigned to line handler and rigger duties. (Dylan McCord / U.S. Navy)

Hospital Corpsman Daniel Camilli, left, and Boatswain's Mate 1st Class Kevin Kellam, right, clean a passage on CG-71 *Cape St. George* in the Persian Gulf on 9 February 2012. A good old-fashioned swabbing of the decks keeps them clean and washes away salt accumulations that can cause slippery footing. (Christopher Johnson / U.S. Navy)

Interior Communications Electrician 3rd Class Jonathan Hart performs maintenance on a stabilized glide slope indicator aboard *Monterey* (CG-61) when the ship is moored in Funchal, Portugal on 26 December 2013. The indicator is a landing aid used by an approaching helicopter pilot to make a safe recovery at sea. (Billy Ho / U.S. Navy)



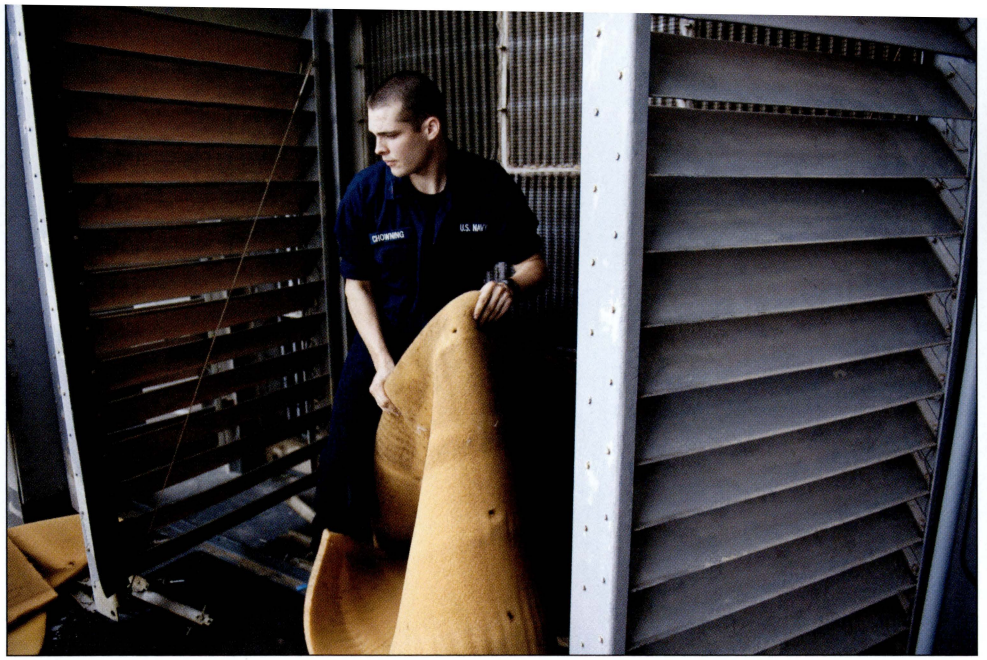
Petty Officer Eugene Gant observes a contact on the horizon through the "Big Eyes" binoculars while on the signal bridge of USS *Cape St. George* (CG-71) on 29 March 2003. Fast combat support ship T-AOE 8 *Arctic* sails nearby. Underway replenishment must account for any vessels in the vicinity. (Michael W. Pendergrass / U.S. Navy)

Gas Turbine Systems Technician Steven West looks at engine performance data and reports his findings as CG-54 *Antietam* cruises in the Solomon Sea on 13 July 2013. The dynamic functions are laid out on the screen in a logical pattern. The parameters are easy to view and monitor. (Declan Barnes / U.S. Navy)

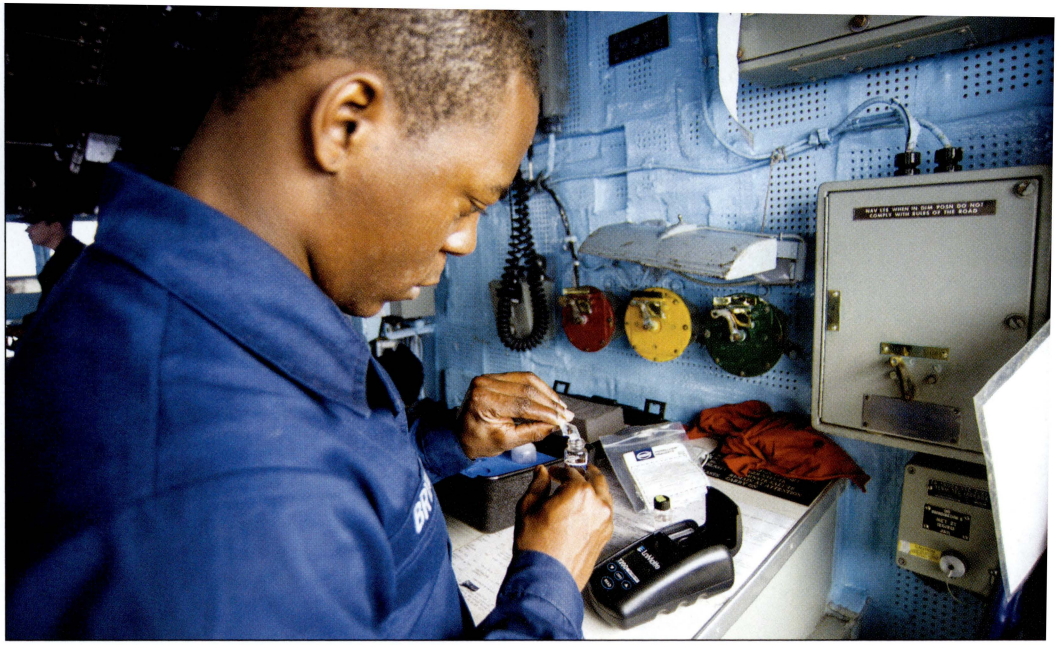
Damage Controlman 2nd Class David Morales operates a manual valve on a hydraulic control manifold on *Antietam* (CG-54) in the waters near Guam on 8 June 2015. Wherever possible, there are manual backup levers to direct the flow of hydraulic fluid if automatic systems fail or if a leak must be isolated for repair. (Ricardo R. Guzman / U.S. Navy)

Petty Officer 1st Class Jessica Bonilla, a sonar technician, is on watch as the surface warfare coordinator on *Cowpens* (CG-63) in the western Pacific Ocean on 12 June 2011. The console to her left in the CIC is a UYQ-21. The display is an advanced video processor that shows tactical data. (Ross Taylor / U.S. Navy)

Chief Gas Turbine System Technician Joel Villaflor communicates with the bridge during engineering operational tests on *Cowpens* in the port of Yokosuka in Japan on 25 May 2010. Consoles show the statuses of many components from the engines to generators. Although highly automated, manual intervention is an option. (Devon Dow / Navy)

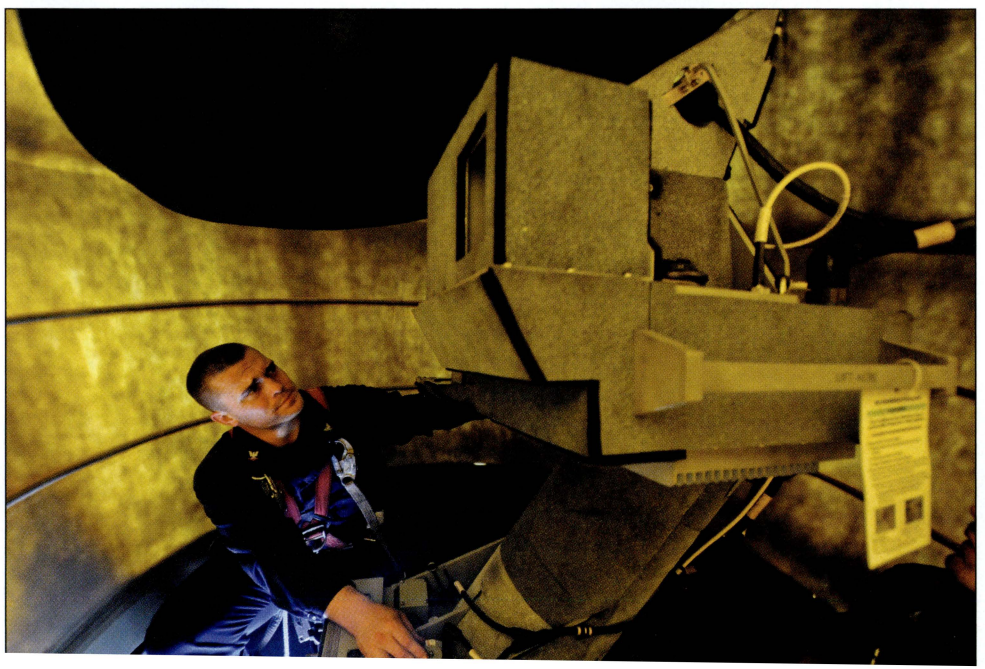


Gas Turbine System Technician 3rd Class Matthew M. Chowning removes and rinses air filters from the ship's engine intakes on CG-66 *Hué City* in the 5th Fleet area of operations on 1 April 2013. Filters are regularly cleaned to ensure the engines can draw the most possible air. Clean air prevents wear from sand and salt. (Matthew R. Cole / Navy)

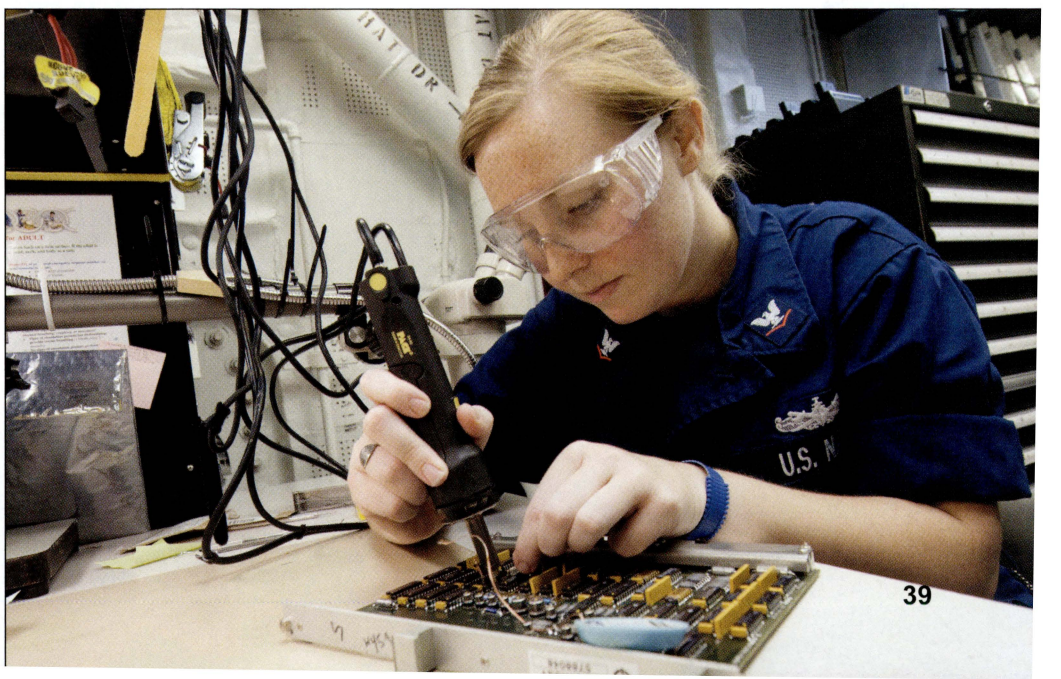


Hospital Corpsman Brandon Bryant conducts a pH balance test of the potable water on CG-54 *Antietam* in the Indo-Asia-Pacific region on 3 June 2015. Many naval vessels have the capability to produce potable drinking water. He ensures the results are within ph levels from 6.5 to 8.5, which is considered safe. (Ricardo R. Guzman / U.S. Navy)

Electronic Technician 3rd Class Robert Taylor works inside a radome on CG-68 *Anzio* in the Arabian Sea on 16 October 2011. The enclosure contains a WSC-6 AS-4431 antenna. This super-high frequency unit moves to compensate for ship motion to maintain a signal lock for message traffic to flow uninterrupted. (Brian M. Brooks / U.S. Navy)



Electronics Technician 3rd Class Meagan Bramble works on a circuit board aboard CG-66 *Hué City* in the Arabian Sea on 20 August 2012. An electronics repair shop is one of many departments that keeps equipment in an operational status. After tests the circuit board will be repaired or replaced in the original hardware. (Darien G. Kennedy / Navy)



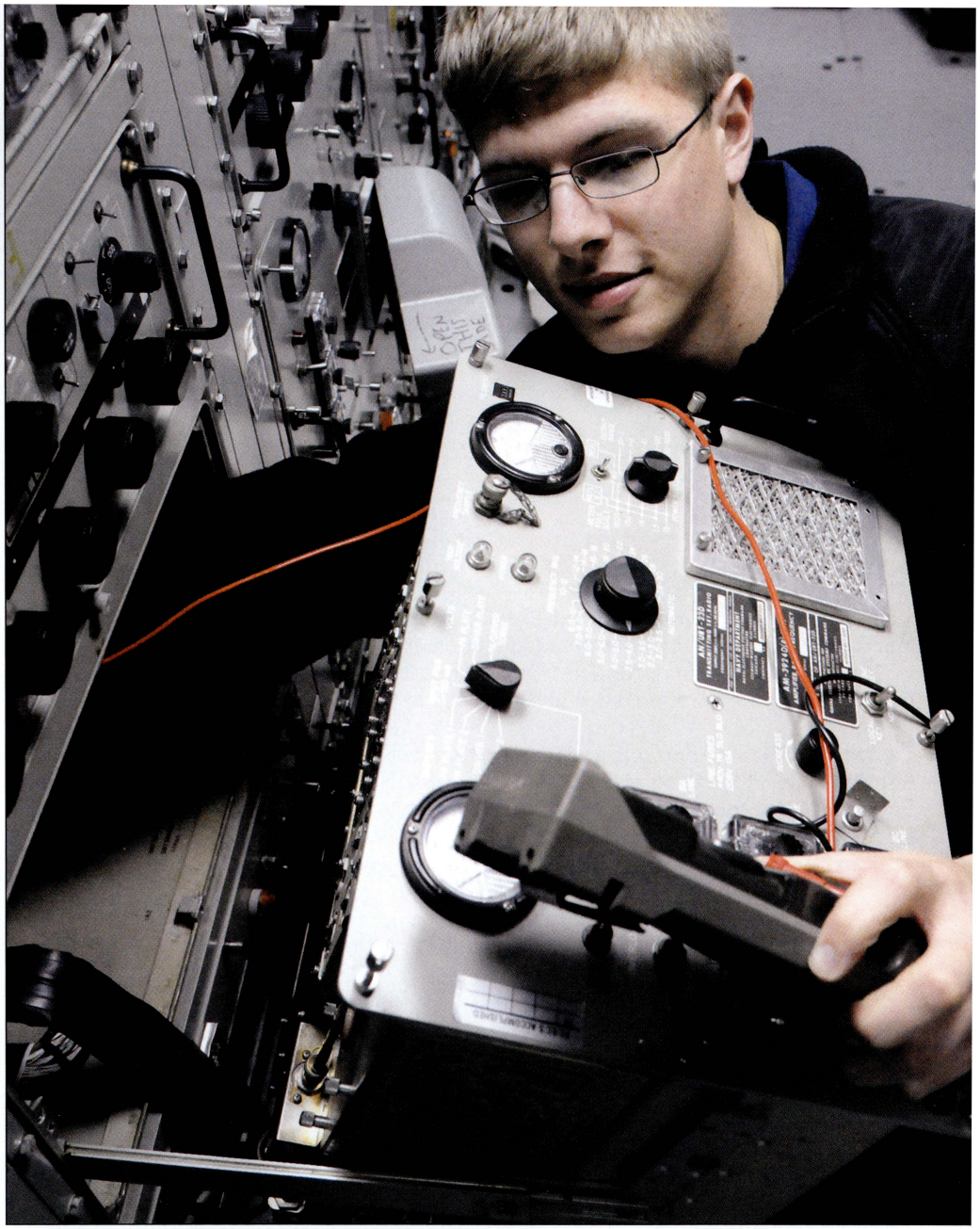
Hull Technician 3rd Class Joshua Johnson creates a shower of sparks as he grinds a part in the general workshop of CG-71 *Cape St. George* on 15 June 2012. In cases where an old part is no longer useful, a new one can be made. A hose reel with hose and an attached nozzle is in place if a fire breaks out. (Christopher S. Johnson / U.S. Navy)

Engineman 2nd Class Zachary Quinones, from Portland, Oregon, inspects fuel on the flight deck of CG-53 *Mobile Bay*, on 5 December 2012. One simple way to check for fuel contamination is to swirl the liquid inside a clear container. Any particles will show at the bottom of the container. (Armando Gonzalez / U.S. Navy)

Maneuvering injured people on a warship is a challenge. With a training casualty strapped into a litter, the process to transport a victim from an accident scene to the medical department is planned out by a detail on board CG-53 *Mobile Bay* on 18 February 2013. Rails are avoided to keep the victim safe. (Armando Gonzalez / Navy)

Gas Turbine Systems Technician Dale Kaiser checks a JP-5 jet fuel sample below deck during a refueling at sea on CG-66 *Hué City* on 11 September 2012. JP-5 is used as aviation fuel for the embarked helicopters. Purity and chemical content are checked prior to use in actual flight operations. (Darien G. Kennedy / U.S. Navy)

Lt. j.g. John Cabigon, from Ewa Beach Hawaii, plots a surface contact on a chart as Chief Warrant Officer 2 Richard Lutte observes from the bridge aboard guided-missile cruiser *Cowpens* (CG-63) on 1 July 2004. Ships must note nearby ships and the courses each will take. Vessels display day shapes to indicate their status to other ships. Radios, blinkers and signal flags are some other methods ships relay messages and inform each other of their intentions. (Lowell Whitman / U.S. Navy)



Electronics Technician 3rd Class Brian Mackey tests the ground key line for a URT-23D radio transmitting set aboard the CG-63 *Cowpens* in the western Pacific Ocean on 16 June 2011. These racks are designed to be accessible for tests. If any are found to be defective, they can be swapped out for the same parts while the bad parts are sent to the repair department for evaluation or replacement. Backup sets are used to avoid any loss of capability until the unit returns to service. (N. Ross Taylor / U.S. Navy)

Chief Hospital Corpsman Edward Lennon helps Boatswain's Mate Seaman Rutchal Mandafe inventory a search-and-rescue medical kit aboard CG-66 *Hué City* in the Gulf of Oman on 21 February 2010. The bag contains items like drugs and saline, which must be inspected for expiration dates and replaced at times. (Matthew Bookwalter / Navy)

Sailors from CG-61 *Monterey* participate in a swim call in the Mediterranean Sea on 3 November 2013. A rigid-hull inflatable boat observes and a life ring is at the ready as safety precautions while sailors enjoy a swim. *Monterey* was deployed in security cooperation efforts in the U.S. 6th Fleet area of responsibility. (Billy Ho / U.S. Navy)

Ensigns O.J. Washington, left, and Richard Kreutzer scan the horizon for surface contacts from the port bridge wing of CG-61 *Monterey* in the Gulf of Oman on 4 November 2008. Ensign Washington prepares to take a bearing while ensign Kreutzer reports via radio. A team effort is required to spot and track contacts. (William Weinert / U.S. Navy)

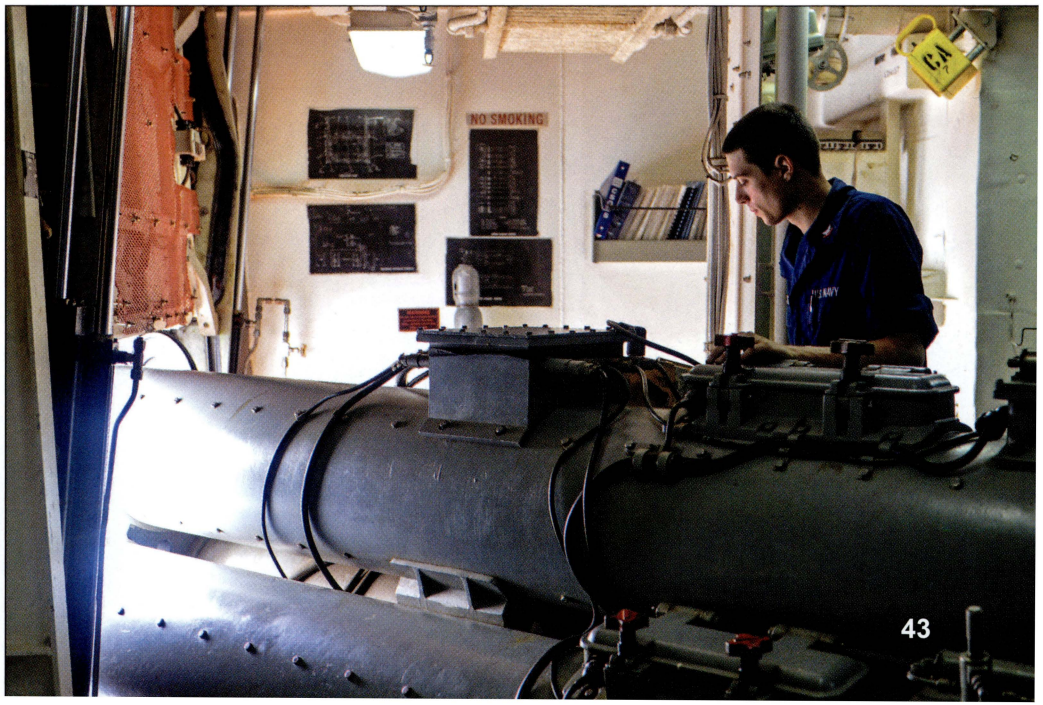
Command Master Chief Mack Ellis, left, and Ensign Jenean Beers stand at parade rest during a burial-at-sea ceremony held aboard guided-missile cruiser *Lake Erie* (CG-70) off the coast of Hawaii on 20 February 2008. Military funerals pay respects to those who have served the nation. (Michael Hight / U.S. Navy)

Quartermaster Seaman Heather Lamb reviews navigational charts in the chart room of CG-54 *Antietam* in the Philippine Sea on 25 September 2013. The charts are kept updated and any notes on hazards, tidal concerns, port entry and exit changes are all annotated for future reference. (Declan Barnes / U.S. Navy)

Sailors assigned to CG-63 *Cowpens* take the Navy-wide petty officer 2nd class advancement exam on the mess decks in the western Pacific Ocean on 13 September 2012. In addition to all other duties crew members must perform, they are encouraged to study and advance their careers to higher ranks. (Paul Kelly / U.S. Navy)

Fire Controlman 2nd Class Nathaniel Hebert inspects a Mk 99 transmitter prior to performing maintenance on CG-52 *Bunker Hill* in the Pacific Ocean on 9 August 2012. The Mk 99 radars guide SM-2 missiles to their targets. Four of these radars are used on this class of vessel. (Shannon Heavin / U.S. Navy)

Gunner's Mate 2nd Class Joshua Fredericks performs maintenance on a Mk 46 Mod 5 torpedo launcher aboard CG-61 *Monterey* in the Arabian Gulf in 16 June 2013. These triple-tube launchers, which use air pressure to launch the weapons, are hidden behind shutter doors along the aft sides of the hull. (Billy Ho/U.S. Navy)



Quartermaster Seaman Recruit Khori Potter plots a course as *San Jacinto* departs the port of Victoria in the Seychelles on 14 June 2010. Factors such as wind, current, tides, and time are noted as well as when buoys or other waypoints are reached. Radar is also used as another input to maintain correct position. (Ja'lon A. Rheinhart / U.S. Navy)

Rear Adm. Mike White, commander of Carrier Strike Group (CSG) 11, speaks with sailors aboard CG-59 *Princeton* during an all-hands call in the western Pacific region on 30 April 2013. Such gatherings give everyone a chance to hear the latest news in the Navy, ask questions and hear about latest fleet developments. (Jason Behnke / U.S. Navy)

Ensign Israel Isip, left, supervises technicians Renmin Oliva and Michael Lynch as they man damage control stations during a chemical, biological and radiological attack training exercise aboard CG-57 *Lake Champlain* (CG-57) in the Arabian Sea on 31 December 2010. Gloves and hoods help protect sailors from fire. (Michael O'Day / Navy)

Logistics Specialist 2nd Class McKenzie Starks checks the stock number of a box of projector lamps in inventory aboard CG-61 *Monterey* in the 5th Fleet area of responsibility on 12 October 2013. Every consumable item brought aboard must be inventoried and recorded. Drawers are bar-coded for quick retrieval of items. (Billy Ho / U.S. Navy)

Quartermaster Seaman Matthew Rivera signals initial contact via Morse code from CG-52 *Bunker Hill* to sailors aboard CVN-70 *Carl Vinson* during an underway replenishment in the Atlantic Ocean on 10 March 2010. The two ships will maintain approximately 200 feet of separation at a speed of 13 knots or "Romeo Speed". (Daniel Barker / U.S. Navy)

A deck detail sweeps away snow from the decks of CG-72 *Vella Gulf* in the Black Sea on 31 January 2012. Not all cruises are warm and tropical. The non-skid deck coating is useless if too much snow or ice builds up. A year-round naval presence in all weather conditions is an essential element of a defense strategy. (Brian Glunt / U.S. Navy)

Crewmen use sledge hammers to break up a thick accumulation of ice on the aft deck of CG-72 *Vella Gulf* while on theater and maritime security operations in the U.S. 6th Fleet AOR in the Black Sea on 31 January 2012. The decks must be kept as clear as possible, especially if the helicopter is intended to be used. (Brian Glunt / U.S. Navy)

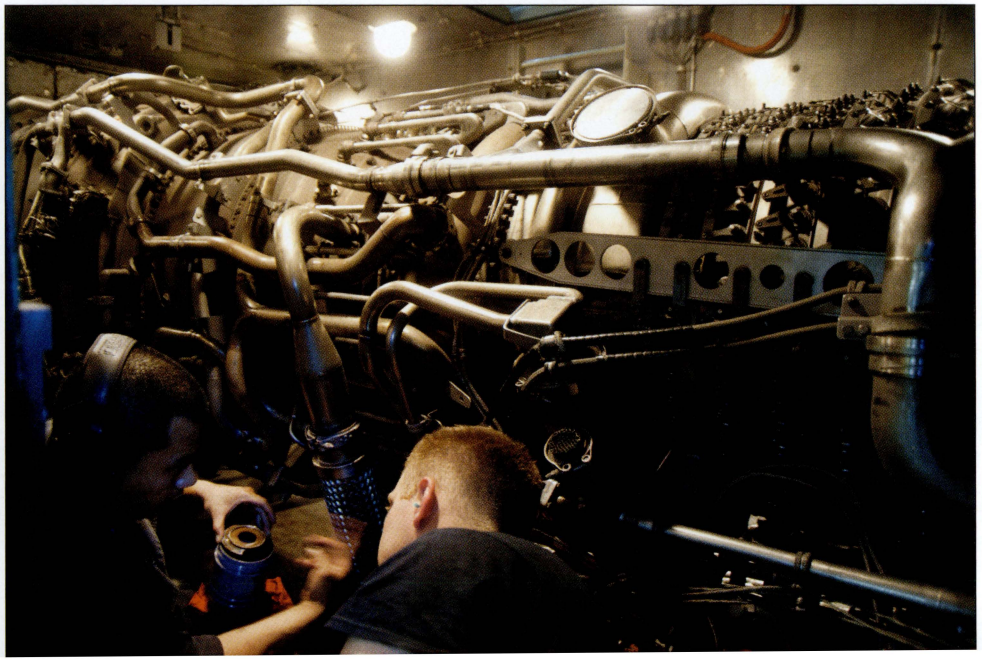
A sailor hoists the National Ensign on CG-56 *San Jacinto* at Staten Island's Stapleton Pier on the first day of the 20th annual Fleet Week New York City event on 24 May 2007. Behind the two sailors is a single empty RGM-84 Harpoon launch canister. Below the Ensign is a fairlead for a tactical towed array sonar or TACTAS. (Jason B. Trevett / Navy)

Seaman Apprentice Leonard Shepard throws a heaving line from the forecastle of CG-61 *Monterey* on 21 October 2013 in Souda Bay, Greece. A port visit begins by securing bow, spring and stern lines, adjusting fenders, and connecting to shore water and power sources. The crew will then have some leave and time ashore. (Billy Ho / U.S. Navy)

Gas turbine technicians watch as Dennis B. Wright, center, performs maintenance on the LM2500 engine aboard CG-56 *San Jacinto* on 3 November 2002. There are four LM2500 engines that are capable of a sustained combined shaft output of 86,000 horsepower. They drive two variable-pitch five-blade propellers. (Michael W. Pendergrass / U.S. Navy)

Sailors aboard CG-64 *Gettysburg* perform a man-overboard drill in the Gulf of Oman on 30 November 2013. With the simulated call of a man overboard, a rigid-hull inflatable boat is lowered from the davit. Lines wrapped loosely around cleats ensure that the boat does not sway as it descends to the water. (Lorenzo J. Burleson / U.S. Navy)

Gas Turbine System Technicians Darwin Demeterio, left, and Cori Johnson work on one of the three 2,500 kw generators on board aboard CG-64 *Gettysburg* in the Gulf of Oman on 2 January 2014. Each generator is inside a thermal acoustic protective enclosure. The combined electric output of the three units is 7,500 kw. (Lorenzo J. Burleson / Navy)



A crack remains in the hull of CG-59 *Princeton* on 21 February 1991 after it was damaged when it struck an Iraqi mine in the Persian Gulf three days earlier in support of Operation Desert Storm. The deck surface has shifted and opened. Modern warship construction accounts for potential damage while it ensures that a hull design can tolerate at-sea stresses such as hogging, sagging, and torsion effects. (Bailey / U.S. Navy)

USS *Mobile Bay* (CG-53) moves slowly as a mine is intentionally detonated nearby in May of 1998. A shock test is performed to ensure that welds, hull plates and interior equipment maintain their integrity and continue to operate after the effects of mine warfare. Sweeping and detecting mines is a major operation. (U.S. Navy)

A sailor works on CG-59 *Princeton* in the Persian Gulf on 21 February 1991. The vessel encountered Iraqi mines and was damaged during Operation Desert Storm. After the hull buckled, temporary repairs were performed in Bahrain. Beams were welded onto the hull to reinforce the weakened sections. Despite this damage, the ship was able to continue tactical operations until relieved. (Bailey / Navy)

A two-person detail advances while scanning for the source of a fire and any sailors who need to be rescued on board CG-61 *Monterey* in the 6th Fleet area on 21 December 2013. A General Quarters drill was called to simulate a fire. Every sailor on the ship is trained in the role of fire fighter and responds when the bell sounds. (Billy Ho / U.S. Navy)

Jonathan Powers uses a Naval Firefighter's Thermal Imager while Thomas Kramer stands by during a damage control drill on *Hué City* (CG-66) on 1 October 2012. Fire response teams use a thermal imager to check for heat signatures as they suppress flames, rescue any victims and ventilate smoke overboard. (Darien G. Kennedy / Navy)

A fully-protected crewman on board CG-67 *Shiloh* moves up a passageway with a fire extinguisher on 11 September 2014. In many cases, fires can be found and extinguished with a portable device. The extinguisher is a pressurized vessel that uses nitrogen to expel a dry chemical agent to smother a fire. (Kevin V. Cunningham / U.S. Navy)

Hull Technician 1st Class Joseph Volz instructs a fire protection crew during a damage control exercise in a smoke-filled space on CG-68 *Anzio* in the Atlantic Ocean on 30 March 2015. The smoke is an inert compound used to add realism to the scene. Searches will be conducted in all areas to ensure a victim is not overlooked. (Abe McNatt / Navy)

Machinery Repairman Brandon Woodard, right, supervises as sailors place a metal shoring post against a bulkhead during a damage control drill aboard CG-64 *Gettysburg* in the Gulf of Oman on 12 August 2011. The post reinforces damaged hull plates. Speed is emphasized but not at the safety risk of any individual. (Betsy Knapper / U.S. Navy)

Yeoman Nelson Munoz mans the Firemain Control Panel during a General Quarters drill on CG-67 *Shiloh* in the Pacific Ocean on 7 December 2004. He watches and acknowledges alarms as the panel illuminates different sections while a simulated fire occurs. Then, he reports his findings to the incident commander. (Bernardo Fuller / U.S. Navy)

Damage Controlman 1st Class Peter Martinez, right, instructs sailors to patch a simulated ruptured pipe during a training drill aboard CG-64 *Gettysburg* in the Arabian Sea on 20 October 2011. The team placed a rubber sheet over the leak site and secured it tightly with twine to halt the leak pending a permanent repair. (Betsy Knapper / U.S. Navy)

After CG-54 *Antietam* has simulated damage during a general quarters drill, Ensign Jordan Klein plots locations on a damage control chart in support of Talisman Saber 2013 in the Coral Sea on 25 July 2013. He will then direct teams into the area that needs repairs or begin search and evacuation procedures. (Declan Barnes / U.S. Navy)

# *Ticonderoga*-class Interior Construction

Construction methods for *Ticonderoga*-class ships are the same as any other warship. Work is performed in phases. The interior compartments are designed on paper. In the yard, the actual metal is cut to create passages, hatches and door openings. With the hull sections joined together, the internal work can begin.

Duct work for air conditioning requires ducts shaped to bend around corners and follow unusually-angled paths. Ducts must be installed in sections before the sections are joined together. Each section of duct work must connect properly into air handling units and have other accessories like heat detectors and dampers included. All of this work must be completed before the next phase can begin.

Wiring can be a simple cable for a display monitor, or it can be a huge bundle of wires run into many components. Wiring harnesses are also designed before they are brought aboard. All design must be finished for the next step to be done.

As the wire installation crew exits, the next crew can fabricate racks for radios, radar electronic components, intercommunications devices and more. Once this crew has performed the necessary additions, yet another team fits large-screen monitors in place.

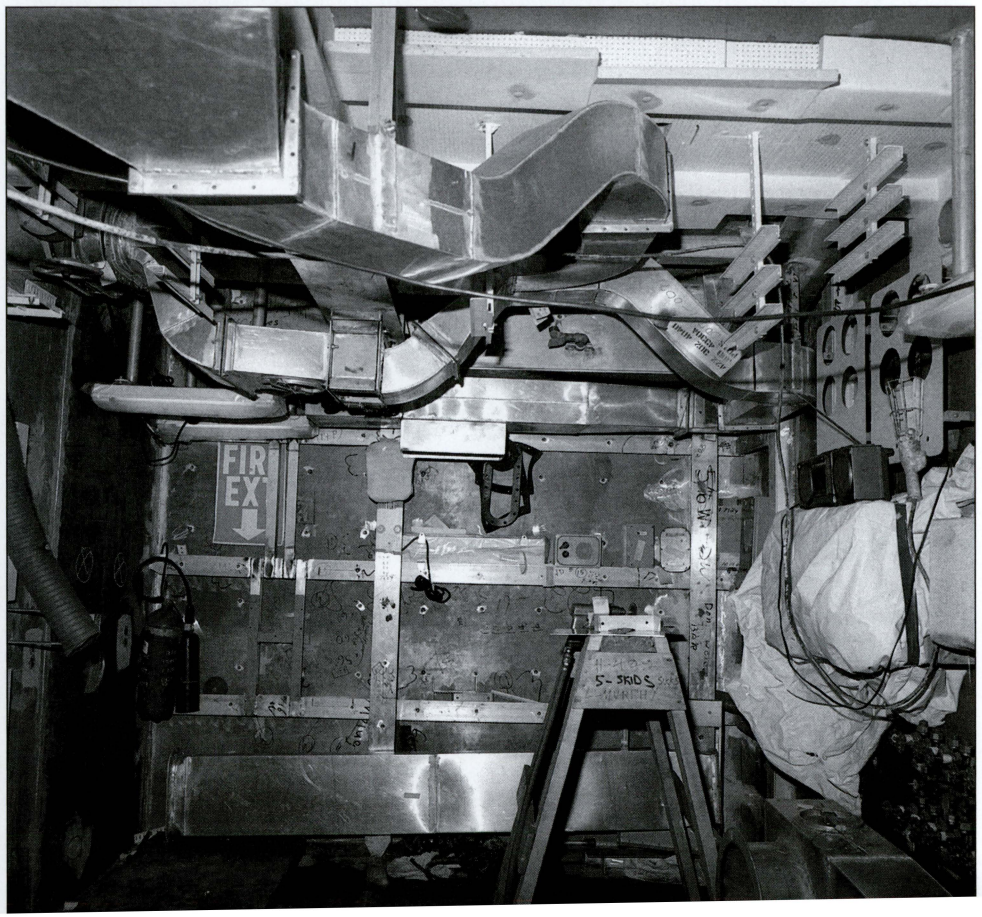
Through multiple crew shifts, the entire ship is alive with action for 24 hours each day until the ship is completely outfitted for its intended roles at sea. This choreography is monitored and inspected as the process moves along. Work stops along the way for updates, team coordination, and any parts-related slowdowns. Unforeseen obstacles must be addressed and modified to maintain the schedule to the best of everyone's abilities.

Work continues as everything is designed, outfitted and tested to ensure everything works in harmony for the ship's lifetime, which in many cases can be 40 or more years in fleet use.

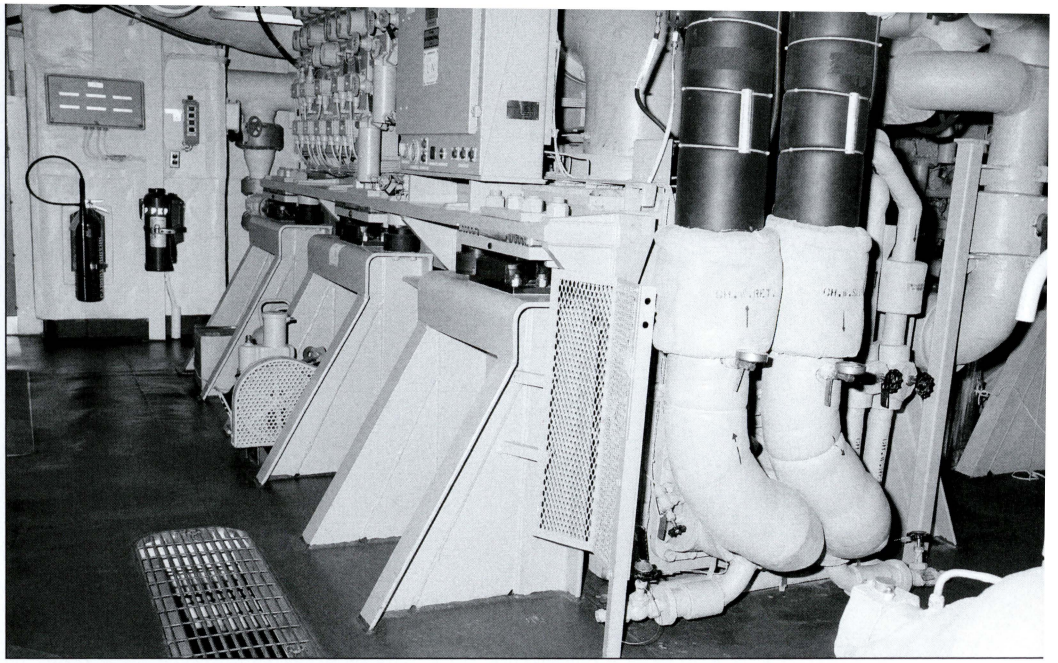
Consequently, a warship is in constant action form the time the first metal is cut. Many designers and installers, welders, fitters, workers, and inspectors perform their duties to create the world's finest naval vessels. These ships must be able to perform a multitude of tasks in a demanding and unforgiving environment.

**The combat information center on CG-67 *Shiloh* is 60 percent completed as construction continued at Bath Iron Works in Maine on 25 October 1992. (Bath Iron Works / U.S. Navy)**

**The electronic warfare room of CG-60 *Normandy* is 40 percent completed during construction at Bath Iron Works in Maine on 17 November 1987. (Bath Iron Works / Navy)**

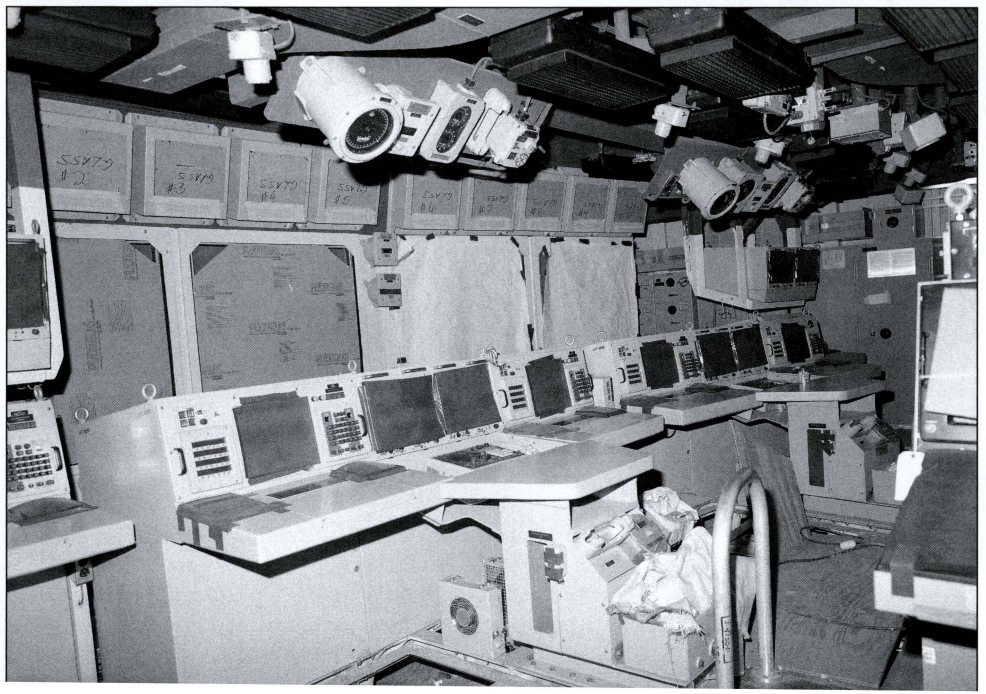


The Aegis radar room No. 1 on CG-64 *Gettysburg* is 70 percent complete on 22 February 1990. The aft part of one of the radar arrays is set at a precise angle. The arrays must all be in correct alignment to work together. (Bath Iron Works / U.S. Navy)

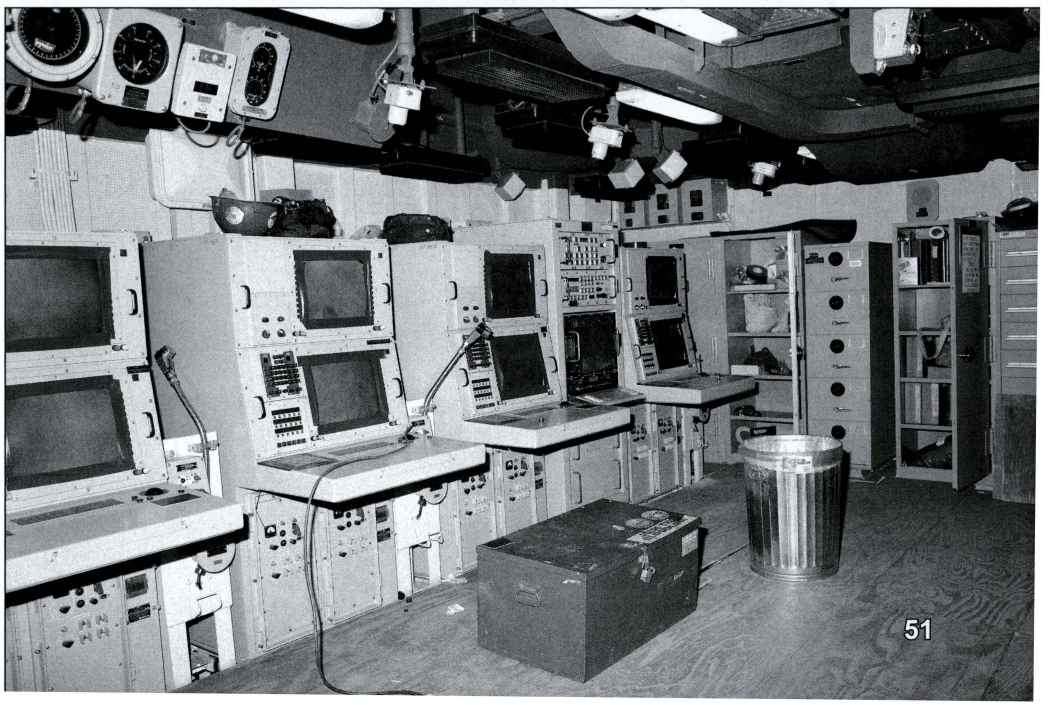


Auxiliary engine room No. 1 is completed on CG-60 *Normandy* at Bath Iron Works in Maine on 29 November 1989. Deck supports, panels, air intake and exhaust lines are all in place. After test runs, it will be declared ready for sea duty. (Bath Iron Works / Navy)

The combat information center is 80 percent finished on CG-70 *Lake Erie* on 5 March 1992. Layout of consoles, radar screens, and overhead instruments are in place. All of this equipment will be connected and tested. (Bath Iron Works / U.S. Navy)



USS *Lake Erie* (CG-70) sonar room is 80 percent done at Bath Iron Works in Maine on 5 March 1992. The four operator consoles, user manual cabinet, secure materials drawers and sonar equipment racks are all in place. (Bath Iron Works / U.S. Navy)



USS *Cowpens* (CG-63) breaks away after an at-sea refueling from T-AO 193 *Walter S. Diehl* on 5 July 2012. Chaff and Nulka launchers are loaded. The device below the starboard CIWS is an SLQ-32 electronic warfare array. The radome on an angled pedestal between CIWS mounts is an IT-21 antenna. Deck areas within red stripes are danger zones and are to be avoided by the crew while various equipment operates. Next to the chaff launcher is a deck floodlight. It is shrouded to direct light to a desired area. (Paul Kelly / U.S. Navy)

A BQM-74E Aerial Target Drone launches from the flight deck of CG-63 *Cowpens* on 19 February 2005 off the coast of Okinawa, Japan. The objective of the missile drill is for other ships to detect, track and conduct intercept drills against the target while it simulates either an aircraft or a sea-skimming anti-ship missile. (Kaitlyn Vargo / Navy)

Aviation Structural Mechanic Antonio Guerrero takes a panel off of a BQM-74E after it was recovered on 19 February 2005. A post-flight series of inspections and refurbishment is done before the drone is placed back in service and fired. After flying has ceased, a parachute deploys to lower the drone into the ocean for pickup. (Kaitlyn Vargo / Navy)

A BQM-74E Aerial Target Drone launches from the flight deck aboard CG-63 *Cowpens* on 19 February 2005 off Okinawa, Japan. The BQM-74E weighs 455 pounds and has a wingspan of 5.78 feet. It can hit speeds of more than 515 knots with a range of more than 350 nautical miles. Its endurance is 1 hour, 18 minutes. (Kaitlyn Vargo / U.S. Navy)

A DC-130H Hercules drone control aircraft of the 6514th Test Squadron passes over CG-65 *Chosin* on 1 May 1991. It carries a pair of AQM-34 Firebee drones. These drones were launched later as targets for the ship's Aegis radar system. Each drone weighs 2,150 pounds. It has a wing-span of 12.9 feet. Its height is 6.7 feet. (Michael Haggerty / USAF)

Rounds impact the ocean surface as sailors assigned to CG-62 *Chancellorsville* fire an M-240 machine gun during a live-fire gunnery exercise in the Philippine Sea on 10 August 2015. Hitting a target from a moving platform is difficult. It is a skill the crew must learn to operate these weapons. Afterward, the deck is cleared of brass. Then, the gun is stripped, cleaned, lubricated, inspected, and stored. (Raymond D. Diaz III / U.S. Navy)

Justin Pruett, bottom left, and Robert Watterson, bottom right, fire M-14 rifles as Lt. j.g. Bryce Brown, left, Nathan Rose, and Ensign Matthew Curley track the shots from the helicopter landing deck of CG-55 *Leyte Gulf* in the Gulf of Oman on on 4 May 2011. The spotter reports hits and gives correction instructions for misses. (Robert Guerra / Navy)

Visit, board, search and seizure team members work on rifle handling techniques on CG-56 *San Jacinto* in the Arabian Gulf on 7 January 2014. This team trains together to sharpen skills and ensure a safe and swift outcome. (Preston Paglinawan / U.S. Navy)

Gunner's Mate Charles H. Talbert fires a dual-mount .50-caliber machine gun during a certification exercise on CG-68 *Anzio* in the Atlantic Ocean on 14 May 2011. The gun can engage slow aircraft, drones or small boats. Everyone wears helmets and body armor. Armor shields along the mount deflect incoming rounds. (Brian M. Brooks / U.S. Navy)

Quartermaster 3rd Class Jacob Worden mans a M-240B machine gun during a general quarters drill on the starboard bridge wing on CG-68 *Anzio* on 31 March 2015. The M-240 machine gun has a wide range of motion on a pintle mount. (Abe McNatt / U.S. Navy)

A SCAT (small craft action team) is deployed on the bow of CG-69 *Vicksburg* before a boarding drill in the Atlantic Ocean on 23 June 2007. From the bow of a *Ticonderoga*-class cruiser, visibility is unrestricted and the team can alert others of impending danger via an intercom set connected to the group's headsets. (Oscar Espinoza / U.S. Navy)

Gunner's Mate 1st Class Ivan A. Wilson fires two M-240B machine guns simultaneously as links and spent brass land on the deck of CG-58 *Philippine Sea* in the Atlantic Ocean on 15 August 2013. This model of the 7.62mm weapon has a folded bipod, iron sights and Picatinny rails to attach a light or laser. The twin setup doubles the firepower and is still useful if one weapon malfunctions. (Brian Reed Castillo / U.S. Navy)

Ensign David Gayle fires a 40mm grenade from a M203 grenade launcher while Chief Lawrence Klein supervises on CG-61 *Monterey* in the Mediterranean Sea on 6 November 2013. The grenade launcher fires a variety of grenades, which include high explosive fragmentation, buckshot, smoke, illumination, and training rounds. (Billy Ho / U.S. Navy)

Sailors fire M-9 handguns during a small arms qualification on the helicopter landing deck on CG-61 *Monterey* in the Arabian Gulf on 10 June 2013. With cramped interior spaces below deck, shooting situations with a minimum of distance between opponents is common and skills are refined by firing at paper targets. (Billy Ho / U.S. Navy)

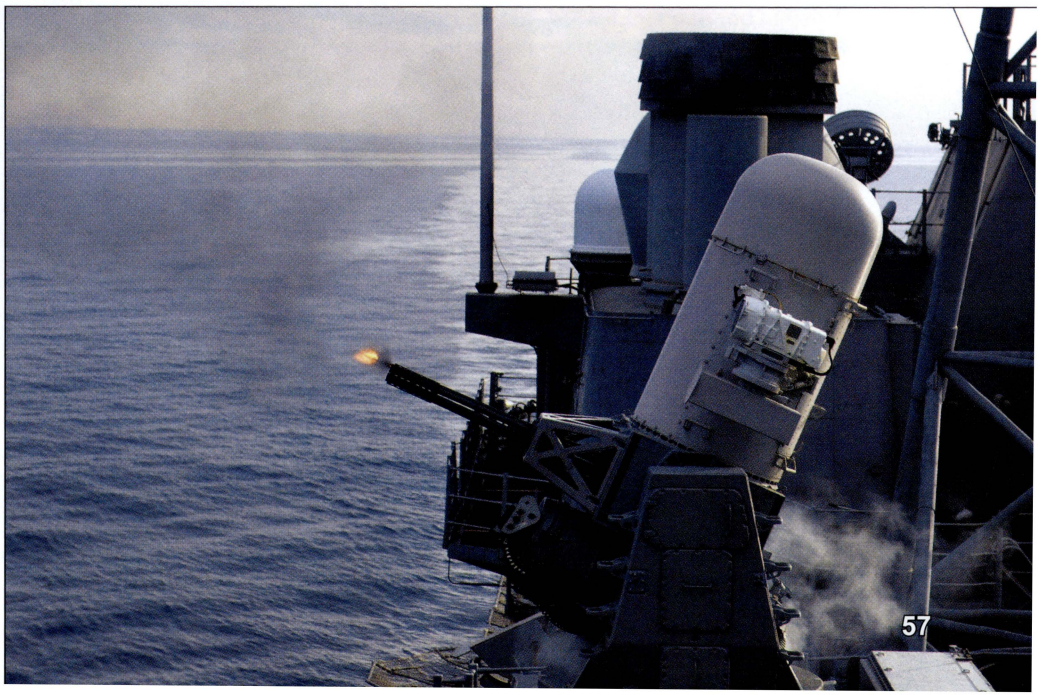
Sailors Alexander Castillo, left, and Cyrus Fluitt fire M-9 Beretta service pistols during small arms qualifications aboard CG-57 *Lake Champlain* in the Arabian Sea on 29 December 2010. The foreground weapon has discharged its last round as indicated by the slide, which is now in the locked and open position. (Michael O'Day / U.S. Navy)

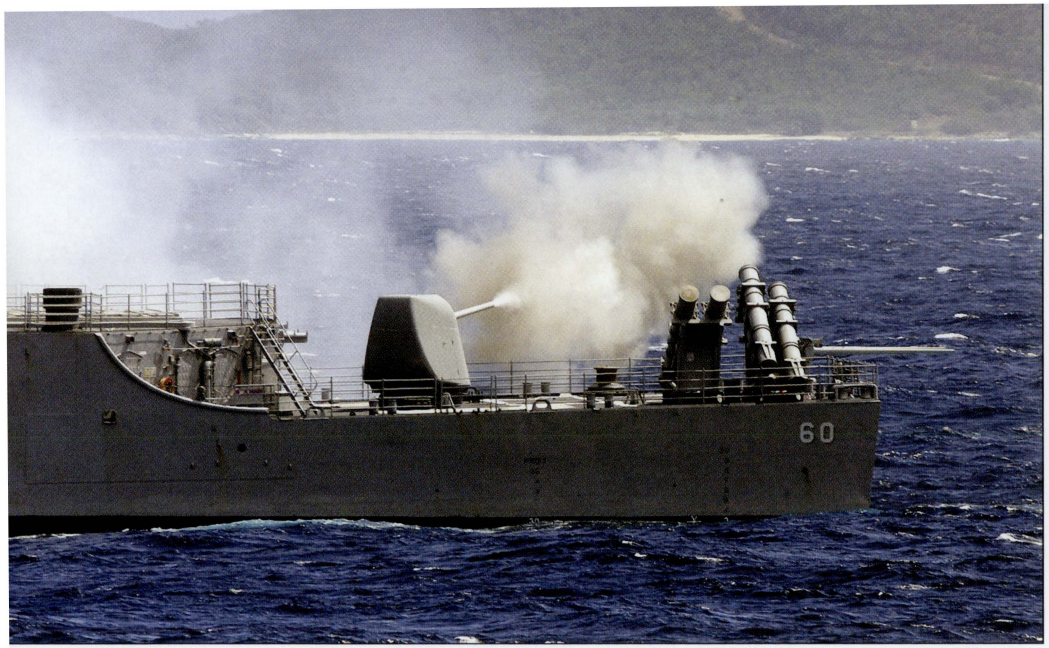
A Phalanx CIWS is maintained by a fire control department crew on CG-63 *Cowpens* in the 7th Fleet area of responsibility in the East China Sea on 2 July 2012. As the weapon is loaded, the crew inspects other items such as linkages, lubrication, safety wires on bolts, electrical plugs and wiring before a live-fire occurs. (Paul Kelly / U.S. Navy)

Fire Controlman Aaron L. Barnard, top, observes as Jeffrey A. Brickson loads the Close-in Weapons System aboard CG-55 *Leyte Gulf* in the Atlantic Ocean on 14 January 2011. The CIWS shoots down aircraft and missiles, but it can also fire at drones and small boats after a series of upgrades. This Block 1-B version has an extended support bracket for the gun barrels. Above the bracket is an electro-optical (E/O) tracking device. The unit has an ammunition capacity of 989 rounds of 20mm shells. Other CIWS Block 1-B users include Bahrain, Canada, Egypt and Japan. (Robert Guerra / U.S. Navy)

A "killer tomato" is bracketed by rounds fired from a CIWS Block 1-B on CG-61 *Monterey* in the Arabian Gulf on 15 September 2013. When surface targets are engaged, the gun fires a manually-aimed 50-round burst. After a two-second delay to assess damage, it can be fired again if needed. Target range can be provided by a ship-board radar or by the installed CIWS radar inside the cylindrical radome above the gun. (Billy Ho / Navy)

A Phalanx CIWS on CG-61 *Monterey* fires at an aerial target in the Mediterranean Sea on 27 April 2013. The unit above deck weighs 12,000 pounds. The equipment below deck weighs 466 pounds. The rate of fire is from 1,000 to 3,000 rounds-per-minute. Muzzle velocity is 3,650 feet-per-second. The radar operates in the Ku-band. (Billy Ho / Navy)






USS *Normandy* (CG-60) bombards shore targets with its aft 5-inch gun during a drill on 28 June 2000 off Vieques Island, Puerto Rico. The gun has a range of 14.7 miles at 47 degrees of elevation and 9.2 miles at 85 degrees of elevation. Four RGM-84 Harpoon canisters are visible on the fantail. (Shane McCoy / U.S. Navy)

Guided-missile cruiser *Antietam* (CG-54) fires its forward Mk 45 5-inch gun in the Pacific Ocean on 18 September 2013. The gun magazine can hold 20 rounds. Shell weight is 70 pounds. Rate of fire is 20 rounds-per-minute. The guns can move 30 degrees per second in traverse and 20 degrees per second in elevation. (Declan Barnes / U.S. Navy)

CG-58 *Philippine Sea* fires its forward Mk 45 5-inch gun in the Atlantic Ocean on 30 July 2013. The gases from the powder charge are vented through the barrel, to prevent the turret and spaces below deck from becoming filled with smoke. The Mk 45 weapon system has been in service since 1971. (Brian Reed Castillo / U.S. Navy)

The aft Mk 45 Mod. 4 5-inch gun on CG-53 *Mobile Bay* fires a shell, left, at a distant target during a naval surface vessel support exercise on 5 August 2015. Both guns can be aimed at two different targets and operate independently. The muzzle velocity is 2,650 feet-per-second. Mod. 4 was introduced in 2000. (Ryan J. Batchelder / U.S. Navy)

Gunner's Mate Seaman Apprentice Pedro Beal removes a Mk 45 5-inch powder case from a powder case canister before a towed drone live-fire exercise aboard CG-54 *Antietam* in the Timor Sea on 14 July 2015. The ship's magagine is protected with heat and flame detectors and can be rapidly flooded. (Ricardo R. Guzman / U.S. Navy)

Gunner's Mate 2nd Class Daniel Barrios instructs Seaman Jhonna Ryan on firing systems during a weapons training exercise aboard CG-59 *Princeton* in the Gulf of Aden on 19 October 2012. Hands-on training is documented and eventually results in live-fire sessions as well as maintenance and record-keeping. (Justin E. Stumberg / U.S. Navy)

Gunner's Mate Justin Parrish moves a 5-inch powder case into the Mk 45 gun loading assembly before a live-fire gunnery exercise on CG-62 *Chancellorsville* near Japan on 30 September 2015. The loading mechanism feeds a projectile and then a charge from the magazine into the breech to be fired through the barrel. (Raymond D. Diaz III / Navy)

The 5-inch gun loading crew awaits orders as they monitor systems on board CG-63 *Cowpens* while in the South China Sea on 4 October 2012. The actual gun turret is unmanned. All of the activity takes place below deck, where the rounds are stored and operations are performed. Each cruiser has two 5-inch guns. (Paul Kelly / U.S. Navy)

# Chaff Use in Modern Naval Combat

All U.S. Navy ocean-going warships have chaff-dispensing capability. Launchers, and rounds are stored in a protected magazine. Chaff rounds are used to protect the ship from attacks by radar-guided anti-ship missiles. With the extensive proliferation of hostile missile systems, anti-ship missile defenses are vitally important. No modern naval vessel can survive without missile countermeasures once combat begins.

The Aegis radar gives ship commanders long-range air and surface search capabilities to detect and provide advance warning about enemy actions and to allow counter actions. Command options range from missile interception to electronic deception.

Large warships employ layers of defensive options simultaneously. Chaff is one method used. Other methods include active electronic counter-measures, such as Nulka hovering decoys and the Phalanx close-in weapon system (CIWS).

When chaff is used, several rounds are dispersed over a wide area because the launch tubes are angled at several degrees to create a huge cloud of foil strips, which are released as the round bursts open. Chaff is deployed as the ship quickly moves to escape the area. Evasion maneuvers help present a smaller radar return to the missile. The approaching missile homes in on radar reflections in the target area, detects the chaff cloud and is attracted to this large radar signature. The hostile missile then explodes harmlessly inside the blooming cloud of chaff foil ribbons.

The *Ticonderoga* class were not designed with any radar-reducing (stealth) hull or superstructure features. More so, no warship of substantial size can be made completely invisible to radars. Consequently, more emphasis is placed on a ship's ability to be warned an impending attack early and to have an effective on-board means to defeat such threats.

**Guided-missile cruiser *Philippine Sea* (CG-58) fires a single chaff round during a live-fire drill on 15 August 2013. In combat, many chaff rounds are fired simultaneously to create a cloud of radar-reflecting foil streamers. This cloud provides a large radar return to mislead a missile. (Brian Reed Castillo / Navy)**

**Cryptologic Technician 2nd Class Daniel Carns loads a chaff round into the decoy launching system aboard CG-62 *Chancellorsville* in the Philippine Sea on 1 September 2015. The Mk 137 muzzle velocity is 75 meters per second. There are batteries of launchers on the port and starboard sides. (Raymond D. Diaz III / U.S. Navy)**

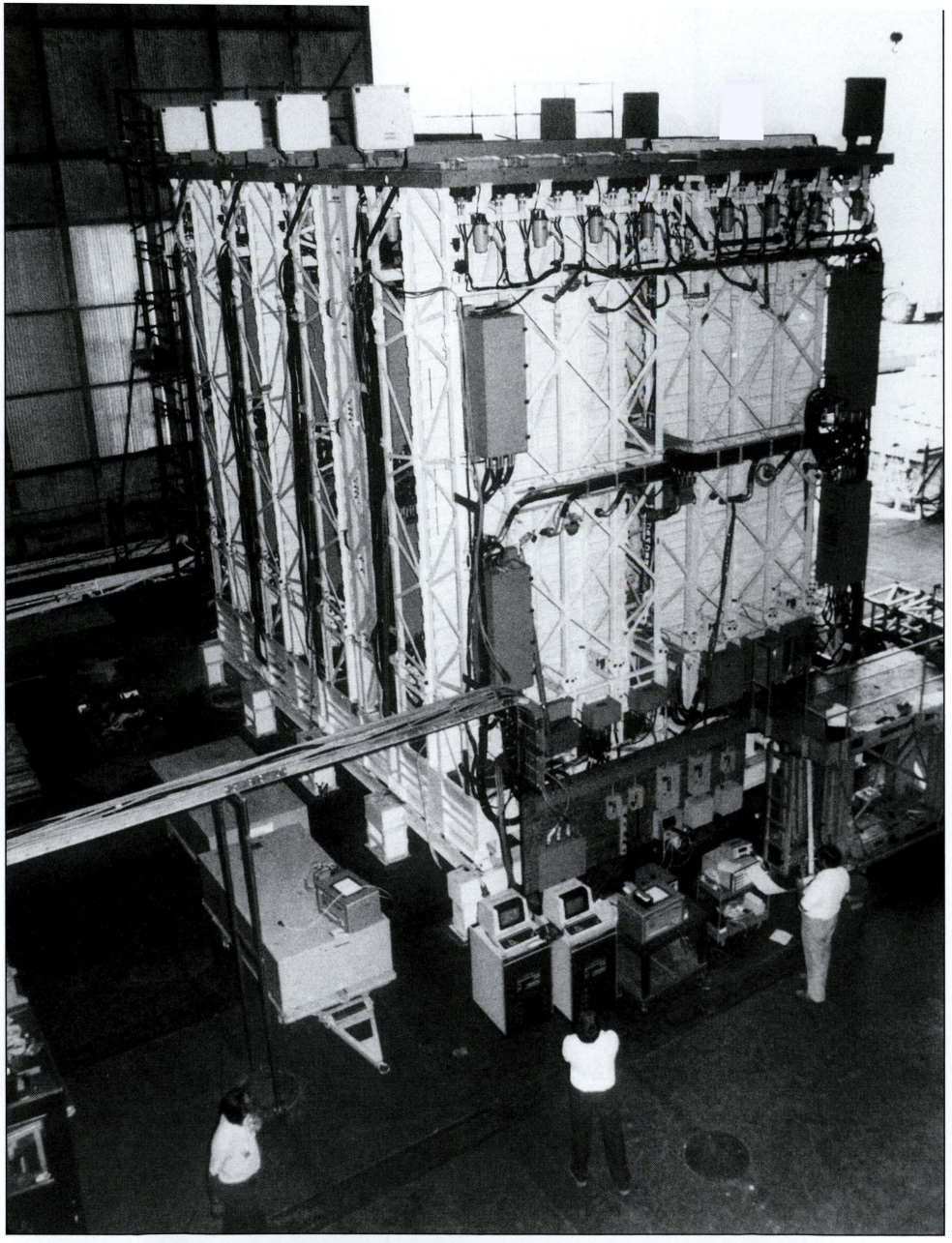
Kevin O'Connell-Keleghan secures a crane hoist onto an RGM-84 Harpoon anti-ship missile on *Antietam* on 20 May 2015 in Yokosuka, Japan. Eight can be attached to the Mk 141 shock hardened stand-alone launcher. The canisters are angled at 35 degrees. The missiles remain sealed until used or maintained. (Ricardo R. Guzman / U.S. Navy)

A Harpoon missile streaks away from CG-67 *Shiloh*, during a live-fire drill on 15 September 2014. The yellow band on the forward section indicates a live warhead. The two brown bands symbolize a live rocket motor. Around 8,000 missiles have been built since 1977. Allied naval forces have about 4,000 of them. (Kevin V. Cunningham / Navy)

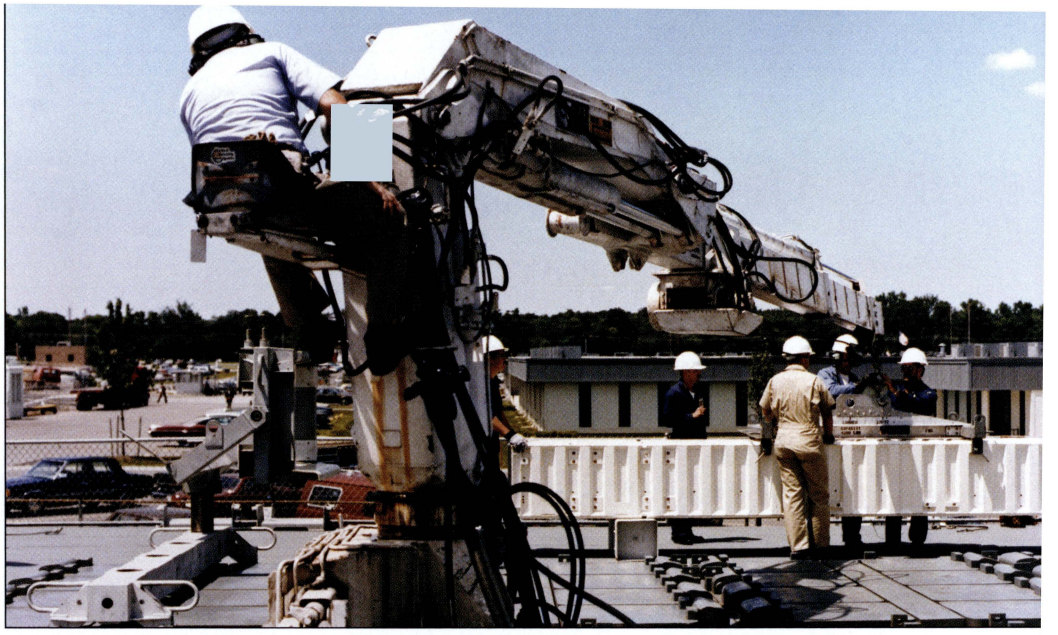
USS *Cowpens* (CG-53) fires an RGM-84 Harpoon in the Pacific on 12 September 2012. Harpoon anti-ship missiles have a range of 75-80 nautical miles. It weighs 1,503 pounds and has a 488.5-pound high-explosive semi-armor-piercing warhead. The white booster motor provides 12,000 pounds of thrust for 2.9 seconds. (Paul Kelly / U.S. Navy)

The Multi-Sail 16 event between U.S. Navy and Japanese surface groups included a live-fire demonstration of an RGM-84 of from CG-62 *Chancellorsville* near Guam on 10 March 2016. The missile seeker can be turned on at a pre-set distance or activate immediately after launch. The ship fire-control system is known as SWG-1. (Matthew Riggs / Navy)

A Standard Missile-3 (SM-3) Block 1B interceptor missile is launched from CG-70 *Lake Erie* during a Missile Defense Agency and U.S. Navy test in Pacific Ocean on 15 May 2013. The Aegis radar system successfully detected, tracked and guided the missile to the target. The ability of a moving warship to hit and disable or destroy space-based assets expands the SPY-1 engagement envelope to the low-Earth orbit (exo-atmospheric) region where satellites operate to gather intelligence data and of missiles that operate at these altitudes. The SM-3 missile is adapted from the Standard Missile SM-2 Block IV. SM-3 uses the same Mk 104 rocket motor and Mk 72 booster, but it adds an advanced solid axial stage dual-pulse motor. The EX-142 light-weight atmospheric projectile homing vehicle is attached to the motor. It searches for the target at altitudes from 300,000 to 400,000 feet once the missile nose cone is jettisoned. Then, it maneuvers by means of the solid-fuel divert and attitude control system. The missile impacts the target without an explosive warhead. Satellite and missiles are made of precision components. Consequently, damage inflicted upon the target missile will cause it to malfunction or self-destruct. (U.S. Navy)



These VLS strike-length modules are used to test the vertical launch ASROC integration with the system on 28 July 1984. The entire module is protected within the hull of the ship. The placement leads some critics to argue there was an apparent lack of weaponry installed as compared to Soviet warships of similar capability. However, vertical launch systems are a very logical and effective means to carry a large number of weapons. A VLS is able to fire with minimal preparation. Vertical launch systems and other variants are now the standard for missile carriages. (United States Navy)

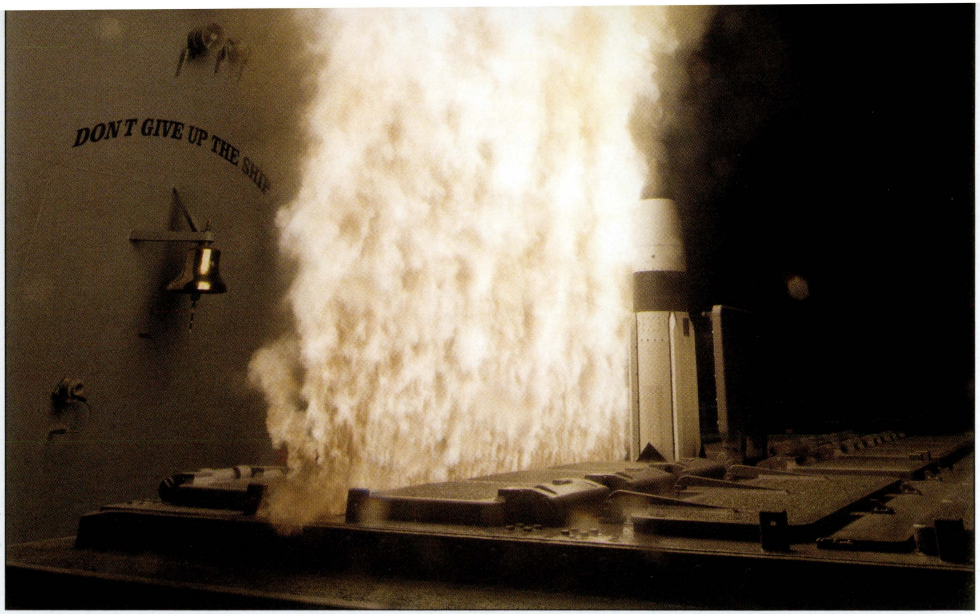


An articulated hydraulically-operated crane reloads a Vertical Launch System (VLS) magazine on 28 July 1984. When the VLS system was initially designed, a loading crane was included for the forward and aft modules. Each crane required the space of three missile cells. Planners eventually decided to eliminate the cranes entirely. (U.S. Navy)

Fire Controlman 2nd Class Andrew Jackson launches a Standard Missile-3 (SM-3) from the CIC aboard CG-70 *Lake Erie* in the Pacific Ocean on 20 February 2008. The missile hit and destroyed the National Reconnaissance Office satellite USA-193. The satellite orbited at 133 miles altitude and a speed of 17,000 mph. (Michael Hight / U.S. Navy)

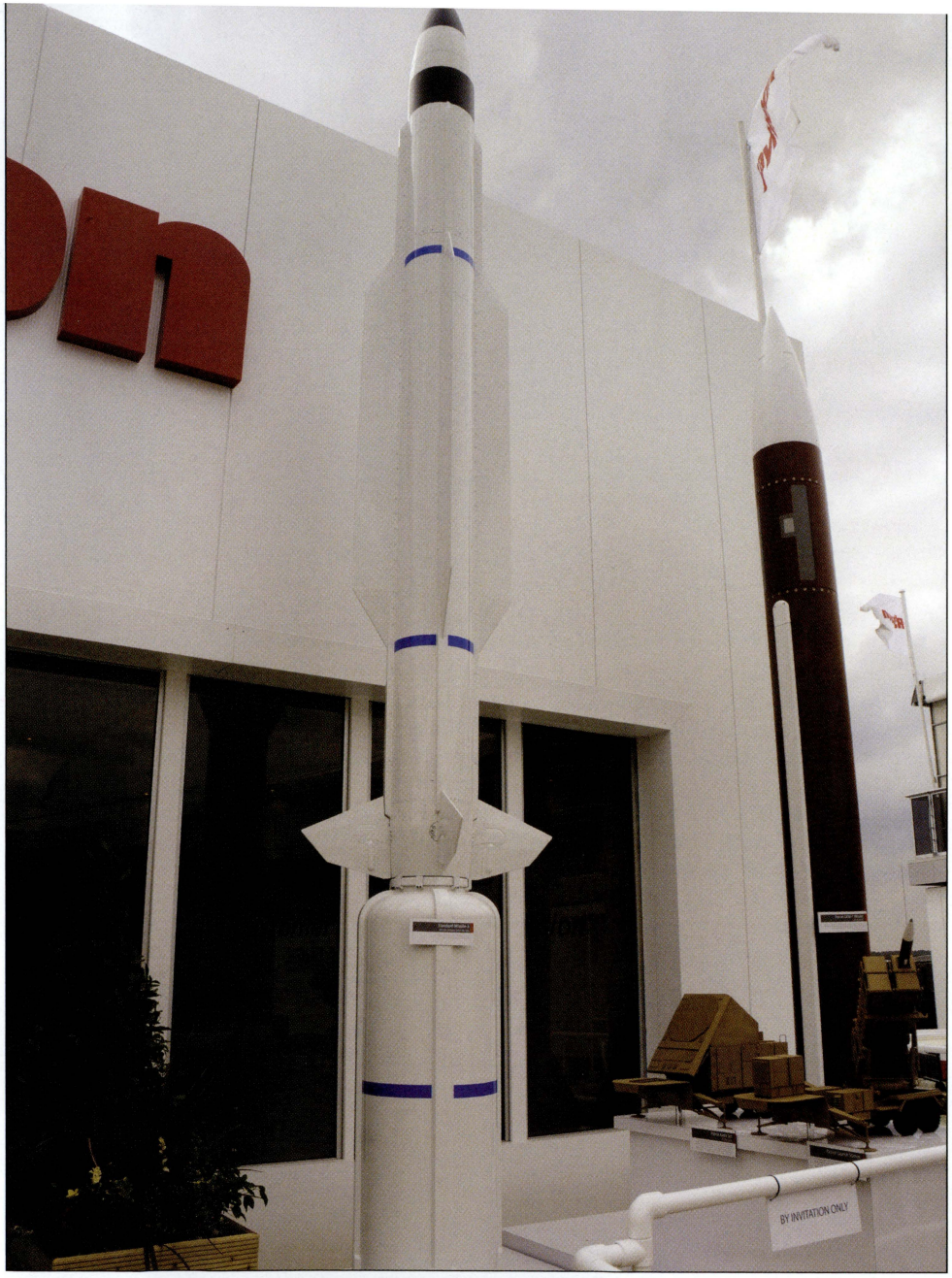
USS *Cowpens* (CG-63) launches an SM-2 from its forward VLS on 20 September 2012. Storing missiles in a vertical position enables weapons to be fired much faster. The module version used on these ships is the strike-length variant, which weighs 485,000 pounds, if it were loaded with 61 SM-2 missiles. Weight increases to 516,000 pounds with a mix of 48 SM-2 and 13 Tomahawk missiles. Power required is 440 volts AC with 115 volts needed for lighting, backup power and launch controls. (Paul Kelly / U.S. Navy)



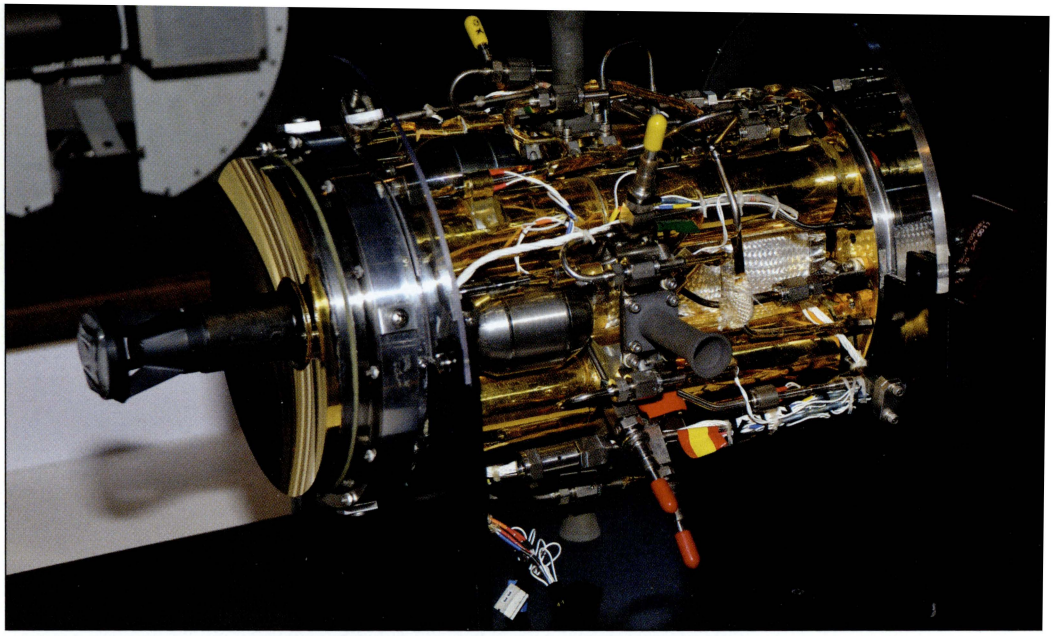



USS *Lake Erie* (CG-70) sends a Standard Missile SM-3 Block 1A into the air to seek out and hit a simulated hostile missile target over the Pacific Ocean on 13 February 2013. The 1A version of the missile gives an initial defense capability against short, medium and intermediate range ballistic missiles. More than 130 have been delivered. (U.S. Navy)

An SM-2 streaks by the bridge windows of the USS *Lake Erie* (CG-70) after it was fired in the Rim of the Pacific 2012 exercises on 15 July 2012. The cropped fins allow for canister storage from which it is launched. The missile weighs 1,558 pounds and is 15 feet, 6 inches long. Body diameter is 13.5 inches. (Derek R. Sanchez / U.S. Navy)

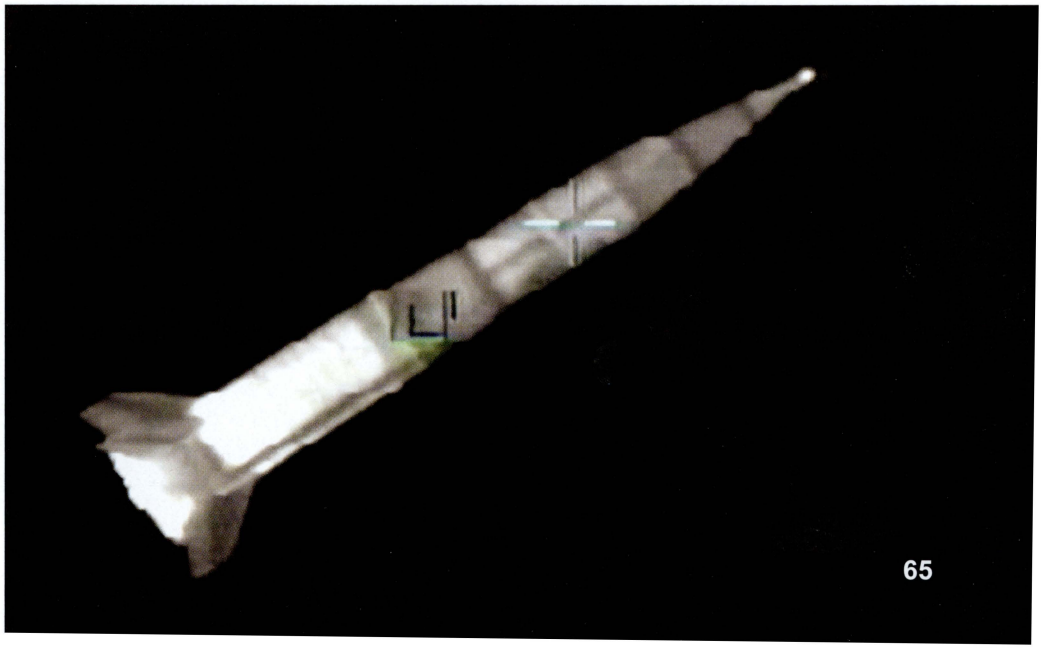



A mockup of the Standard Missile 3 (RIM-161A SM-3) is displayed at the 2010 Farnborough Airshow on 23 July 2010 in Farnborough, England. Its maximum speed is Mach 3.5 with a 150-mile ceiling. Its diameter is 21 inches with a length is 21 feet, 6 inches. The SM-3 has a fins-deployed span of 5 feet, 2 inches. Japan also uses the SM-3, which was designed for ballistic missile defense. The nose fairing contains the third stage, which has the kinetic energy seeker head to damage or destroy the hostile missile. (Author)



A lightweight exo-atmospheric projectile (LEAP) is displayed at the Stephen F. Udvar-Hazy Center Smithsonian Museum Annex at Dulles Airport in Washington, D.C. on 9 July 2013. The forward-looking infrared sensor uses a combination of mirrors and lenses to detect targets. The body contains several thrusters for the solid-fuel divert and attitude control system used to fine tune the flight path to ensure a hit. (Author)

An SM-3 LEAP sensor launched from CG-70 *Lake Erie* prepares to impact an ARIES target missile as it flies at 500,000 feet on 21 November 2012. It was the third consecutive successful intercept. The LEAP payload does not have an explosive warhead. Instead, it uses kinetic energy to simply smash into the missile and break it apart. (U.S. Navy)



A recoverable exercise torpedo is brought back aboard CG-52 *Bunker Hill* in the Arabian Sea on 14 March 2012. The exercise round is used to simulate a real weapon in the water. The crew employs tactics to evade and deceive it. To the round's front is the hull side door from which the torpedoes are fired. (John Grandin / U.S. Navy)

Gunner's Mate Kacy Rupp, left, and Gunner's Mate Andrew Putman remove a Mk 46 torpedo from the Mk 32 Mod 14 service vessel torpedo tube during a torpedo load and reload exercise aboard CG-70 *Lake Erie* off the coast of Hawaii on 17 February 2008. The torpedo has contra-rotating propeller blades for high speeds. (Michael Hight / Navy)

Sailors guide a Mk 46 torpedo across the flight deck during an ammunition transfer aboard CG-64 *Gettysburg* in the Gulf of Oman on 15 July 2011. A live round features a yellow band around the warhead section. The grade of high explosive used is PBXN-103. Warheads weigh 90 pounds, and move as fast as 40 knots. (Betsy Knapper / Navy)

During exercise UNITAS 45-04, CG-51 *Thomas S. Gates* fires a Mk 50 recoverable training torpedo in the South Pacific on 17 July 2004. The Mk 50 is capable of 50-knot speeds and can operate at depths of more than 3,000 feet. The Mk 50 production run totaled 1,083 examples at a unit cost of $2.9 million each. (Ligia Cohen / U.S. Navy)

Sailors aboard CG-63 *Cowpens* receive two pallets of frozen goods, suspended under the yellow trolley from dry cargo and ammunition ship T-AKE 6 *Amelia Earhart* in the Pacific on 16 September 2012. The trolley rolls on a tensioned highline. Below this line is the tensioned inhaul used by the customer to bring the load across. (Paul Kelly / Navy)

Sailors assigned to CG-54 *Antietam* prepare to receive cargo on a standard tensioned replenishment alongside method (STREAM) rig during a replenishment-at-sea with T-AKE 10 *Charles Drew* in the East China Sea on 14 October 2013. The green-helmeted sailor maintains contact with both the guide ship and bridge. (Declan Barnes / U.S. Navy)

Sailors prepare to receive pallets marked HUE on CG-66 *Hué City* during a connected replenishment-at-sea with replenishment oiler T-AO 193 *Walter S. Diehl* on 5 May 2013. A white outhaul fairlead attached to CG-66's kingpost moves items. The white-helmeted sailor is the safety observer. A refueling hose is in use. (Luis Fiallos / U.S. Navy)

Boatswain's Mates Ryan Beaton, left, and Christopher Treanor unwrap pallets of stores aboard CG-64 *Gettysburg* after a replenishment with dry cargo and ammunition ship T-AKE 8 *Wally Schirra* in the Arabian Sea on 18 October 2011. After replenishment, handlers sort and store everything. (Betsy Knapper / U.S. Navy)

Culinary Specialist 2nd Class Ricardo Ortega, from Durango, Mexico, cooks pasta and vegetables for lunch on board on CG-53 *Mobile Bay* in the Philippines' Surigao Strait on 10 April 2013. With a few hundred crew to feed throughout each day, food is created in quantity. Ingredients are proportioned and mixed together. (Armando Gonzalez / Navy)

Lt. j.g. Richard Laffoon moves pizzas into the oven for the crew aboard CG-64 *Gettysburg* in the Gulf of Oman on 23 November 2013. The ship's crew eats in shifts. Sailors on duty eat while others cover in all respective departments. (Lorenzo J. Burleson / U.S. Navy)

Sailors participate in a steel beach picnic aboard CG-58 *Philippine Sea* in the Arabian Sea on 1 June 2014. Picnics gives everyone a break from the dining routine and a chance to eat in an informal setting while sailors play dominoes and other games on the flight deck during a warm day with clear skies. (Abe McNatt / U.S. Navy)

Culinary Specialist Seaman Diante A. Johnson prepares pork chops in the ship's galley for the crew aboard CG-68 *Anzio* in the Pacific Ocean on 24 January 2011. Many main courses are offered during the weeks the ship is underway. Keeping the fleet's deployed ships stocked with dry, frozen and canned food is a monumental task. The logistics involve shore facilities, supply ships and aircraft. (Brian M. Brooks / U.S. Navy)

Royal Malaysian navy officers board CG-53 *Mobile Bay* during a passing exercise in the Indian Ocean on 9 September 2011. The boarding sailor is from guided missile frigate *Lekiu* (FFG-30) while a sailor from the ship *Selangor* 176, a *Meko*-class patrol vessel holds the ladder. (Walter Wayman / U.S. Navy)

Rear Adm. Scott E. Sanders, Task Force 151 commander, speaks with Col. Lofta Al Barati, Aden District commander of the Yemen coast guard, during a visit aboard CG-68 *Anzio* on 12 September 2009. Such meetings benefit both nations as the U.S. and Yemen work together on counter-piracy and anti-terrorism tasks. (Brian K. Fromal / U.S. Navy)

French sailors assigned to the *Aquitaine*-class frigate D652 *Provence* watch a live-fire gunnery exercise from the bridge wing of CG-54 *Antietam* during a bilateral exercise in the Indian Ocean on 11 February 2016. *Antietam* is on patrol in the 7th Fleet area of operations in the Indo-Asia-Pacific area. (David Flewellyn / U.S. Navy)

Capt. Randall M. Hendrickson, commanding officer of the CG-70 *Lake Erie*, speaks with media members after *Lake Erie* fired a modified SM-3 and successfully destroyed a malfunctioning U.S. satellite. The satellite traveled in space at more than 17,000 mph about 150 miles over the Pacific Ocean on 20 February 2008. (James E. Foehl / Navy)

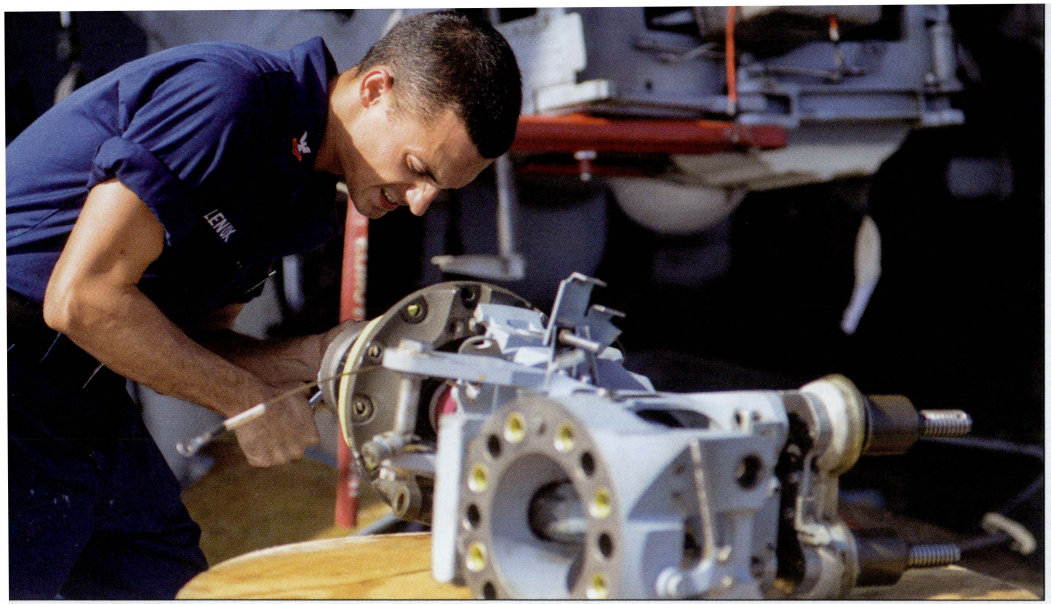
Sonar Technician 3rd Class Jake Watkins, left, and Ensign Stu Douglas participate in a visit, board, search and seizure (VBSS) training exercise aboard CG-54 *Antietam* in the Philippine Sea on 6 June 2014. Such training promotes safe methods to move through and clear a ship full of corners, shadows and hiding places. (David Flewellyn / U.S. Navy)

Members of a VBSS team from CG-64 *Gettysburg* approach the vessel *Is'hak* to capture suspected pirates after responding to a merchant vessel distress signal in the Gulf of Aden on 13 May 2009. *Gettysburg* was part of a multinational task force established to actively deter, disrupt and suppress piracy. (Eric L. Beauregard / Navy)

Lt. j.g Timothy Vadala provides rear security during a VBSS training exercise aboard CG-56 *San Jacinto* in the 5th Fleet Area of Responsibility on 30 September 2013. One team member always faces the opposite direction to provide suppressive fire to the rear and allow the team to disperse and take cover if needed. (Preston Paglinawan / Navy)

*Leyte Gulf* (CG-55) keeps station close by as one of its VBSS team members shakes hands with the master of the Philippine-flagged merchant vessel *Falcon Trader*, which was attacked by pirates on 25 March 2011. A multinational fleet patrols sea lanes off the Horn of Africa, an area prone to acts of piracy. (Robert Guerra / U.S. Navy)

The newest version of the Seahawk series, the MH-60R, warms up on CG-58 *Philippine Sea* in the Atlantic Ocean on 11 August 2013. The MH-60R is an advanced model of the original SH-60B. The assigned squadron is HSM-70 "Spartans." The Squadron code is AJ-710. Bureau Number 167062 stays with the aircraft throughout the time it serves in the fleet. Its home squadron can and does change frequently. At the aircraft's nose is an AAR-44(V) multi-spectral targeting system with a six-axis stabilized turret. It contains a laser designator, infrared imager, and optics with a zoom capability. Below the AAR-44 mount is a radome for the Hawklink data-link system. It transmits data gleaned from the radar, forward-looking infrared sensor or electronic support measures (ESM) gear to the ship in real-time. The square housing to the right of the AAS-44 is an array of ALQ-210 ESM aerials. The aerials detect and classify radio frequency emissions. The small round sensor device next to the ESM array is an AAR-47(V)2. It detects missiles approaching the aircraft and also detects and warns the aircrew when laser energy, used by some anti-aircraft missile systems to obtain range data, targets the aircraft. The shallow circular radome under the forward fuselage contains the APS-153 (A = piloted aircraft, P = radar, S = detecting, range and bearing, search) multi-mode radar. The pylon can carry an auxiliary fuel tank or a rocket pod amongst other items. The rows of empty round tubes aft of the large window are where sonobuoys are loaded and ejected. A charge of compressed air pneumatically-ejects the 25 sonobuoys that the rack can hold. The fairing aft of the national insignia is for an aft-facing ESM ALQ-210 array. The round ventral radome is the aft data-link antenna. The system switches between the two for best reception or transmission for the aircraft and ship orientation. (Brian Reed Castillo / U.S. Navy)




Aviation Electronics Technician Kevin Lenox maintains a main rotor blade hub of an MH-60 Seahawk helicopter aboard CG-61 *Monterey* in the Mediterranean Sea on 4 November 2013. Frequent inspections of dynamic components ensures safety and reliability. All parts can be traced back to their original equipment manufacturer. (Billy Ho / U.S. Navy)

An SH-60B of the helicopter anti-submarine squadron light (HSL) 44 "Swamp Foxes" rests on CG-71 *Cape St. George* on 28 March 2003. The SH-60 tail boom and the main rotor blades are required to be folded when stored aboard ships. This requirement reduces the aircraft-occupied area when on deck or in a hangar. (Michael W. Pendergrass / Navy)

Aviation Machinist's Mate Othello Adou disconnects the T700 engine from an MH-60R Seahawk helicopter during maintenance aboard CG-64 *Gettysburg* in the Arabian Sea on 18 October 2011. A custom-designed bracket was bolted to the engine to allow rapid removal and replacement once the engine work is completed. (Betsy Knapper / Navy)

Aviation Electronic Technician William Moore of HSL-48 loads an ALE-47 aircraft countermeasures ejection flare module with 30 chaff cartridges on CG-66 *Hué City* on 31 May 2013. The chaff flares are electrically fired from the module as needed. To enable the module to function, the lever is moved from SAFE to ARMED. (Luis Fiallos / Navy)

Lt. Cmdr. Gene Malveaux communicates with an SH-60B of HSL-51 before it departs CG-63 *Cowpens* in the Pacific Ocean on 1 July 2004. He is in the helicopter control station on the flight deck. The console has controls for the recovery assist secure-traverse gear used to lower the chopper to the deck in heavy sea states. (Lowell Whitman / U.S. Navy)

Lt. Dan Dolan, left, of Salt Lake City, Utah, and Lt. j.g. Matt Debbink, from Oconomowoc, Wisconsin, of the HSC-4 "Black Knights" fly an MH-60S Seahawk over the Pacific Ocean on 23 June 2014. The instrument panel consists of four main displays, two multi-function displays with hand controllers to enter data. (Jacob Estes / U.S. Navy)

Lt. j.g. Joe Gramata observes an MH-60R recovery from the helicopter control station on CG-64 *Gettysburg* on 22 November 2013. Gauges around the console indicate ship speed, wind direction and ship course. Windows allow views above and around the flight deck. Wipers remove water and debris from windows. (Lorenzo J. Burleson / Navy)

Aviation Warfare Systems Operator Corey Lightfoot tracks a surface contact on an APS-124 search radar of a SH-60B Seahawk during a routine flight mission with the HSL-42 "Proud Warriors" embarked aboard *Vella Gulf* (CG-72) over the Baltic Sea on 9 June 2003. Returns can be sent to the ship in real-time. (Michael Sandberg / U.S. Navy)

An SH-60 of helicopter anti-submarine squadron HS-14 approaches CG-63 *Cowpens* as the ship moves in the Pacific on 26 June 2006. The aft high frequency antenna pair has been lowered to clear the approach. The landing deck is forward of the aft VLS, or B module. The white square-painted area is for vertical replenishment loads intended to be dropped on the aft deck. The steel tube that runs down the side of the helicopter main gear strut is a hydraulic brake fluid line. (Jarod Hodge / U.S. Navy)

Lt. Cmdr. Robert Watts, operations officer on guided-missile cruiser *Monterey* (CG-61), right, and Gunner's Mate Antonio Sanchez hook a cargo pendant onto the cargo hook of an SH-60B Seahawk helicopter of Helicopter Anti-Submarine Squadron Light (HSL) 48 during a vertical replenishment (VERTREP) with T-AKE 3 *Alan Shepard* in the Arabian Gulf on 31 July 2013. This operation can move tons of materials in a short time. (Billy Ho / U.S. Navy)

An inert unguided 2.75 inch folding fin aerial rocket streaks away from the launcher pod on an MH-60R Seahawk of the Helicopter Maritime Strike Squadron HSM-71 "Raptors" while training over the Pacific Ocean on 13 October 2015. (Eric Coffer / U.S. Navy)

USS *Lake Champlain* (CG-57) tops off an SH-60B of the HSL-45 "Wolfpack" during a sea power demonstration in the Pacific Ocean on 3 July 2006. A fueling method known as hover in-flight refueling was implemented and is regularly used on ships not suited for landing operations. The helicopter has an ASQ-81 Magnetic Anomaly Detection (MAD) "bird" array on an aft pylon to detect submarines. (Marc Rockwell-Pate / U.S. Navy)

Sailors assigned to Explosive Ordnance Disposal Mobile Unit (EODMU) 2 Platoon 2-3-2 execute a fast rope insertion from an SH-60F Seahawk onto the deck of CG-66 *Hué City* in the 5th Fleet Area of Operations on 8 September 2012. Quick boarding methods achieve surprise to accomplish safer search operations. (Ryan D. McLearnon / Navy)

# Construction Launch Method

The *Ticonderoga*-class cruisers were built at the Bath Iron Works in Maine. As sections were joined together to form the hull, a cradle was simultaneously erected to support the entire ship until it was launched into the Kennebec River. The cradle basically consists of sliders, a fore poppet, a saddle, solid packing and a stern support.

Large timbers, called sliders, rest atop the two rails, called slipways or simply "ways," that allow the ship to glide into the river at launch. Between the rails and sliders are a combination of wax and grease to help slide both the ship and the cradle into the river.

The fore poppet supports the bow minus the sonar dome. The sonar dome is attached later in dry dock after the launch. During the launch, the fore poppet allows the ship to pivot safely once the stern begins to rise as it moves into the water. The stern's rise causes the bow to drop. To absorb the downward pivot energy, wood beams and plywood sheets inside the fore poppet are crushed and deform as the weight shift occurs.

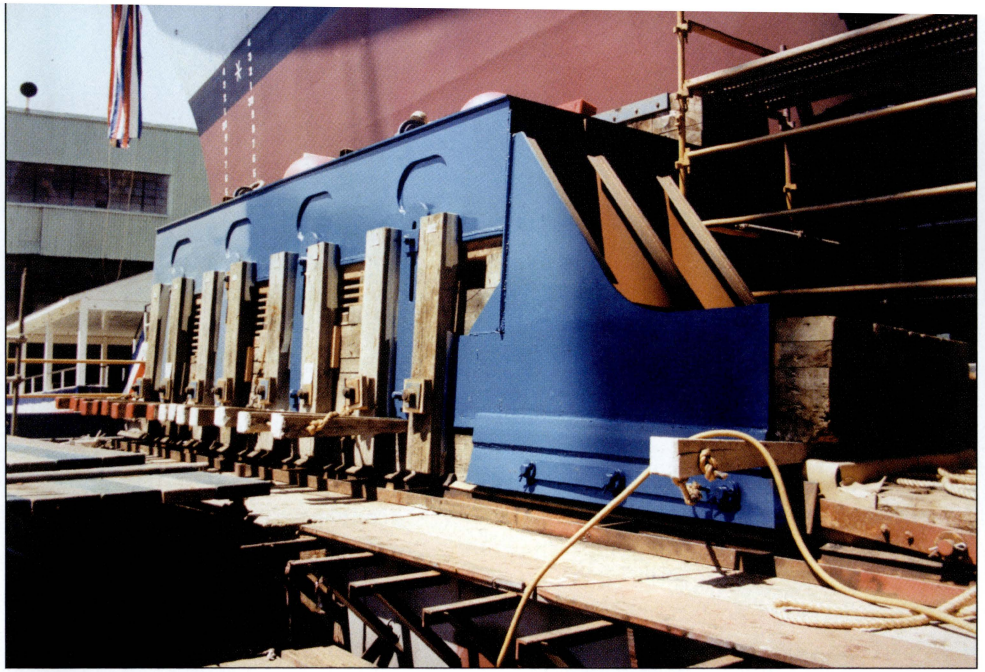
The saddle is a strap of steel running completely across the belly of the ship. It supports the hull near the bow to prevent dislodged sliders. Along the outside of the rails are steel ribbons to secure the sliders as they travel down the rails into the river.

A solid pack of wood beams runs along the hull sides. Planks, known as hutchets, are bolted at 10-foot intervals along the hull exterior. Wires run under the hull and through the hutchets to maintain the solid packing.

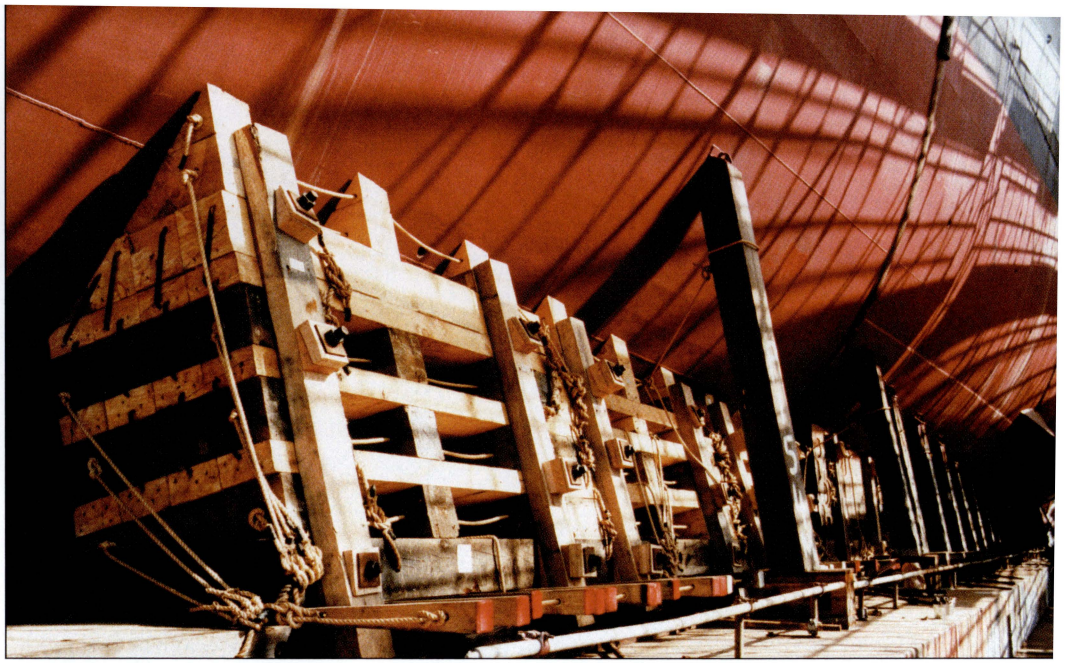
***Normandy* (CG-60) is on the ways on 18 March 1988. A slipway is a ramp to move ships from the shore to the water. The nautical term is sometimes shortened to "ways." When a ship is built upon these ramps, it is said to be "on the ways." (Bath Iron Works)**

**USS *Normandy* (CG-60) is on the ways on 18 March 1988. Two floats are attached to the fore poppet to show its location in the river after the ship launches. (Bath Iron Works)**

**The stern poppet is painted blue under CG-60 *Normandy*. (Bath Iron Works / U.S. Navy)**

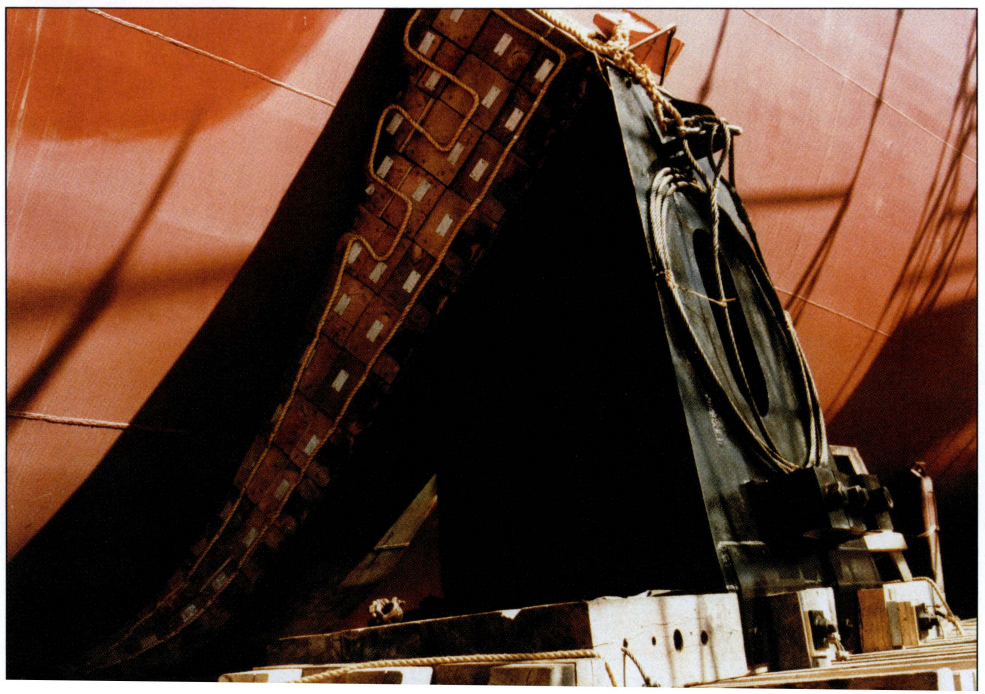


The fore poppet for CG-64 *Gettysburg* is made of plywood sheets and wood beams at Bath Iron Works in Maine on 21 July 1989. As this assembly slides down the slipway, it is crushed to absorb the shock as the ship orients itself. (Bath Iron Works / U.S. Navy)

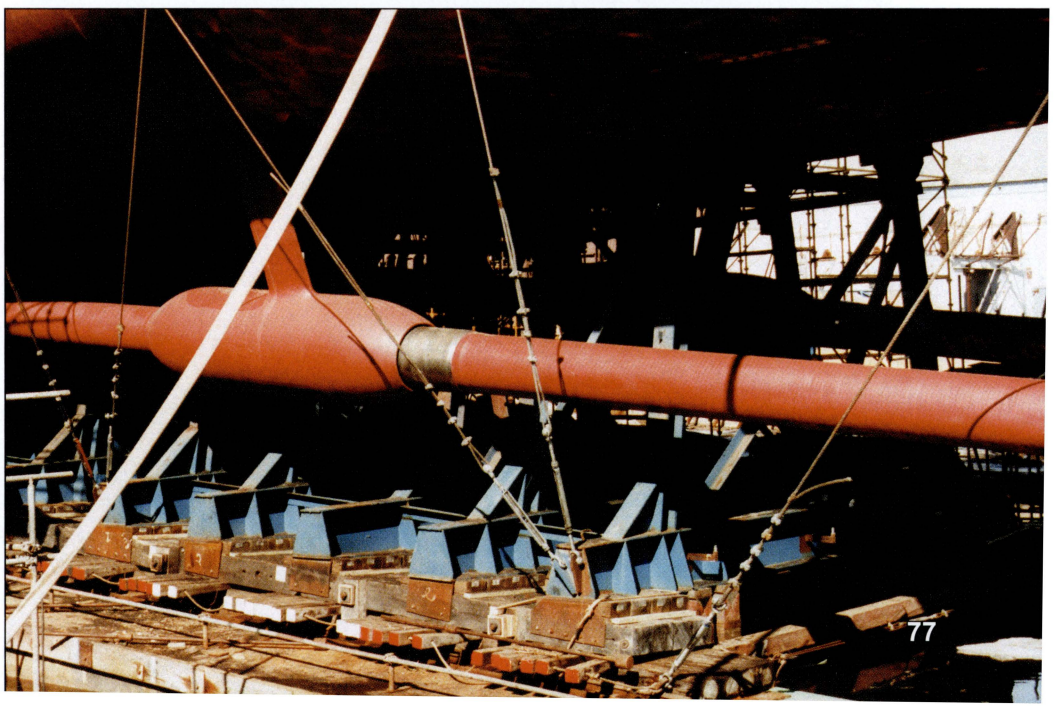


USS *Normandy* (CG-60) has hutchets and tie-rods attached during construction on 18 March 1988 in Bath, Maine. Large steel bolts and nuts keep the entire unit together as it holds the ship in place during its slide down the ways. (Bath Iron Works / U.S. Navy)

Wood blocks fill the void between the hull and a steel strap on the saddle aft of the bow on CG-60 *Normandy* on 18 March 1988 in Bath, Maine. The wood sections are kept from sliding apart by a rope section nailed into the ends of the wood pieces. (Bath Iron Works)



The stern poppet supports the aft hull section of Aegis guided-missile cruiser CG-60 *Normandy* on 18 March 1988 in Bath, Maine. Blue beams hold the stern section up and support this area as the ship slides into the river. (Bath Iron Works / U.S. Navy)



**Guided-missile cruiser *Gettysburg* (CG-64) docks on 11 April 2013 in Mayport, Florida. This ship has not gotten the Cruiser Modernization Program update yet. The SPS-49, electro-optical device and the SPQ-9A are on the foremast platform. (Author)**

**CG-58 *Philippine Sea* was modernized because the SPQ-9B is on a platform behind the USC-38 satcom radome on 11 April 2013 in Mayport, Florida. The SPS-49 is gone as well as the electro-optical (E/O) set. The E/O was replaced by two Mk 20 Mod 0 E/O at the port forward and the starboard rear corners of superstructure. (Author)**

# *Ticonderoga* Systems and Details

The basic hull and superstructure of the *Ticonderoga*-class cruisers adapted over many years to accommodate an assortment of radars, radomes, weapons and antennas. The ships are designed to take all these systems to sea. In addition to the hardware, room is required for an aviation department, crew dining and berthing spaces, food storage, fresh water production and storage, fuel storage tanks, spare parts, electronics, a towed-array, torpedo defenses, an ammunition magazine, anchors, chains, small boats, and more. It quickly becomes clear that careful thought must determine not only onboard placement, but also simultaneous operations of several systems.

Over time, ships change appearance as features are removed and replaced by other items. Changes include enhanced satcom systems with increased bandwidth capacity and increased sensitivity and detection range for radars. These changes usually alter the overall ship profile. It is not uncommon for ships of the same class in the same harbor to have differing equipment on board.

For the *Ticonderoga* class, these upgrades have been beneficial – especially where top-side weight is concerned. The ships are nearly as heavy today as they can safely operate, so any reduction in weight is an advantage. Constant miniaturization of electronic components along with added capabilities means the level of technology is raised while weight is shed.

These ships are festooned with all sorts of masts, antennas, wires, arrays of antennas as well as distinctive single units like a radar. Each item has a specific task that aids the overall ability of the vessel.

Once a threat is detected such as a supersonic sea-skimming cruise missile, the crew must quickly determine if it is indeed a threat, then react. The reactions are available in layers of defense. This first layer of defense is to identify and destroy hostile weapon systems with missiles. If the long-range missile fails, short-range missiles, guns, chaff and decoys and evasive maneuvers can all be employed. All of these options must work perfectly every time they are employed.

The ability to see farther to the horizon is why warship designers place certain sensors like surface search and navigation radars high on the masts to take advantage of the extra height above the ocean surface. This placement also warns the crew early after a threat is discovered. Direction-finding antennas are also located in high mast sections to detect hostile signal energy. When signal energy is directed at the ship, higher antenna placements provide a few extra seconds to protect the ship.

Satellite communication (satcom) systems also require space atop the superstructure and deckhouses. These systems were developed and deployed while these ships were being produced. Satcoms require space to house the dish antennas inside radomes. Space inside the ship is also needed to mount racks of components for these systems to work effectively.

Over time, as space-based platforms became more sophisticated the dishes inevitably grew in size. Larger dishes also meant larger radomes had to be installed to contain the improved systems. While heavy and bulky, the new systems allowed access to more bandwidth and the ability to handle a greater volume of streams of data and video.

Guided-missile cruiser *Philippine Sea* (CG-58) features an SPY-1A conformal radar below the bridge windows on 11 April 2013 in Mayport, Florida. The large radome along the port side is for the WSC-6 super-high frequency satcom. On the main mast, below the JTIDS antenna, are the CEC four-element planar array active antennas. (Author)

The port aft deckhouse of *Vicksburg* features two Aegis AS-3444 fire-control radars in 2013. A commercial satellite telephone radome is at the lower left. A Nulka hovering decoy launch canister and covered chaff launchers are nearby. The light gray square antenna beside the rail is an AS-141 high frequency direction-finding unit. (Author)

The USC-38 radome mount with a faceted base is located between the two Aegis fire control radars on the forward superstructure of *Philippine Sea* (CG-58) on 11 April 2013 in Mayport, Florida. The base was modified to reduce radar reflections in the area. The radome itself is shaped to scatter radar waves away from their emission source. (Author)

The starboard view of the aft deckhouse of the guided-missile cruiser *Gettysburg* (CG-64) features three satcom units on 11 April 2013 in Mayport, Florida. The radome at the corner is the USC-38. The large radome houses the WSC-6. Next to the WSC-6 are the exhaust stacks for the two main engines and one generator. (Author)

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Fleet replenishment oiler T-AO-201 *Patuxent*, left, and guided-missile cruiser *Leyte Gulf* (CG-58) prepare for a replenishment-at-sea in the Atlantic Ocean on 1 December 2013. The *Ticonderoga*-class cruisers have served the United States Navy well and have proven themselves to be capable, adaptable and worthy of the long-term investment funded by the American taxpayer. Built on a *Spruance*-class hull design, the ships have withstood criticism of the appearance of being under-gunned as opposed to Soviet Cold War Era designs. *Ticonderoga*-class ships have shown the flag in ports around the globe, maintained peace, and have effectively protected aircraft carriers with anti-submarine and anti-air systems. Although not stealthy, they can pace nuclear carriers and provide a formidable air and surface defensive capability that will be hard for a future vessel to replace. The men and women who operate these ships do a superb job to keep these assets in constant fleet service as they operate as part of carrier strike groups, respond to natural disasters and calls for assistance. The ability to replenish underway at sea and to fly helicopters and unmanned aerial vehicles (drones) from their decks makes these ships prized platforms that are the envy of naval forces worldwide. The Cruiser Modernization Program will keep these warships viable for years to come. The nation is fortunate to have the "*Ticos*" ready in times of peace, need or conflict. They are well capable to match or exceed any hostile intentions from the ocean depths to space. (Justin Wolpert / U.S. Navy)

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